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ORIGINAL ARTICLES.

I.—Notes on new or imperfectly known Chalk Polyzoa.

By R. M. Brydone, F.G.S.

(*Continued from the January Number, p. 8.*)

(PLATE VII.)

ONE of D'Orbigny's subsidiary methods of classification was to create separate genera for those species which heap layer upon layer of zoœcia by prefixing '*Mult*' or '*Multi*' to the name of the genus to which they would but for this habit of growth be referred. It is rather surprising that he did not have occasion to create a genus *Multeschara*, as there are two species in the English Chalk which he could only have dealt with in this way. They are of interest in their bearing on the question of the admissibility of methods of growth in classifying the Cheilostomata, as they are linked together by a most adventitious peculiarity in growth and one which does not involve any zoœcial modification. They offer therefore a case in which, if those who will not allow to zoarial growth any measure of classificatory value are right, it might be anticipated that species so linked together would be a heterogeneous assembly and not even consistent in this habit of growth. Such an anticipation would hardly be borne out in the case of the English Chalk. The Multescharine habit is practically confined to the two following species, which are most distinctly homogeneous, and neither of which, as far as my experience goes, ever adopts any other mode of growth (except for occasional specimens of *Rhagasostoma palpigerum* of purely Escharine habit, which may fairly be regarded as cut off prematurely in the Escharine stage, through which every '*Multeschara*' must pass). The only other Escharine species which I have ever found in Multescharine habit is the very common form usually labelled *Eschara* (or *Onychocella* or *Rhagasostoma*) *Lamarcki*, Hag., but which I strongly believe to be the original *Eschara irregularis*, Hag.,[1] although neither the figure nor the description is conclusive. After a severe struggle for existence in the zone of *Terebratulina lata* this species rapidly becomes abundant in the Senonian stage, and in its vigorous youth in the zone of *Holaster planus* it frequently assumes a Multescharine habit; but this

[1] Hagenow, *Jahrbuch für Mineralogie*, 1839, p. 264, pl. iv, fig. 2.

development would seem to have proved unprofitable, as it is not repeated, so far as I know, at any later horizon, although the species persisted in Escharine habit to the top of the English Chalk in unabated abundance. But even if this species were grouped on account of its early behaviour with the two following, the group so constituted would be still quite homogeneous, though not so strikingly.

Had a genus *Multeschara* been in existence I should have gladly referred my new species to it, for they are so notably smaller than the average run of Escharine forms that such a treatment would have recognized a very large measure of common zoœcial as well as zoarial character. As it is they are zoœcially Rhagasostomata, and I leave them there.

Rhagasostoma Sussexiense, sp. nov. (Pl. VII, Figs. 1–6.)

Zoarium concentrically multilaminate, branching and very massive; the section figured, which is about 4 cm. in its narrowest dimension, is from a specimen little above the average.

Zoœcia subpyriform, very small, ranging freely in length between ·32 mm. and ·38 mm.; aperture semicircular, with a short rectangular tongue about three-fourths of the width of the aperture projecting into it from the lower margin, leaving a wide deep sinus at either end.

Oœcia very doubtfully present; but a rounded depression occasionally observable at the lower end of a zoœcium may be a relic of an oœcium connected with the preceding zoœcium.

Avicularia shuttle-shaped, with the front wall between the apex and the aperture flush with the side walls; the aperture is central and shaped like a rounded arrow-head, and the sinus which forms the stem of the arrow-head is very narrow and ends in a tiny circular pore.

The species is very prone to ectocystal development; Fig. 4 shows a specimen in which the avicularia dwarf the zoœcia, Fig. 5 a specimen in which the reverse occurs.

Abundant at Seaford and Beachy Head in the upper part of the *M. cor-testudinarium* zone (= Rowe's lower one-fourth of the *M. coranguinum* zone), but very difficult to clean perfectly, the chalk being tenacious. I have not yet observed it elsewhere.

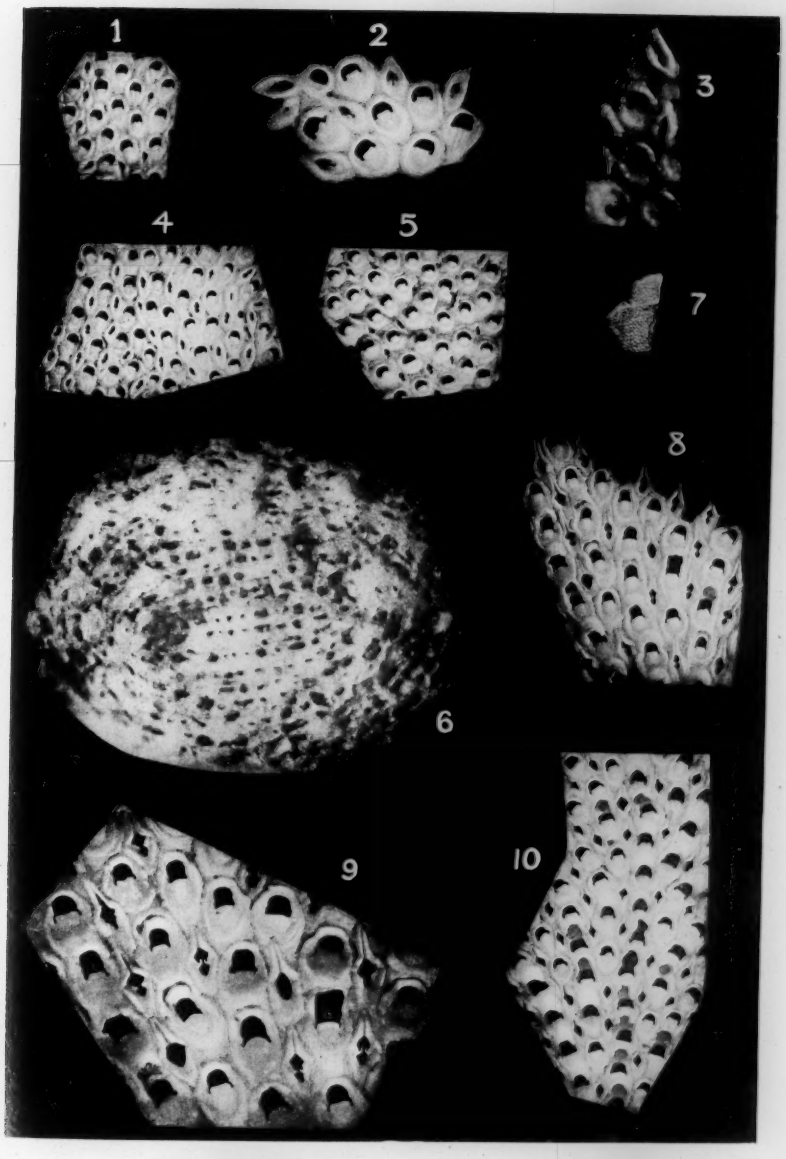
Rhagasostoma palpigerum, sp. nov. (Pl. VII, Figs. 7–10.)

Zoarium branching, with wide but flattish and rather fragile stem.

Zoœcia small, very variable in dimensions, ·4 mm. being a fair average length, but ·35 mm. on the one hand or ·5 mm. on the other being easily found; aperture heel-shaped, with a slightly incurved lower margin; from its corners two long and narrow slits run in a direction at first outwards and downwards, but quickly bending round to straight downwards; the zoœcia remain always distinguishable from one another.

Oœcia large, rather straight-sided, very high at the apertural end, which is heavily cut back, giving a deeply concave free edge.

Avicularia angular, widest round the aperture, with a long, slender, tapering beak with a median furrow; the aperture is roughly



E. M. Bryglone, Photo. Benrose, Cable.

Chalk Polyzoa.

diamond-shaped, with the lower part of the diamond more obtuse-angled than the upper; from the lower angle of the diamond there descends what is probably a fairly wide straight-sided slit, but its edges seem always more or less broken away; in the best-preserved specimens two long and very slender feeler-like processes project into the aperture from either side of the upper end of the slit; when all the fragile part has been broken away the aperture is enlarged into a fairly symmetrical diamond.

This species is very strongly associated with the subzone of *Offaster pillula* (in the zone of *Actinocamax quadratus*) and the immediate neighbourhood of that horizon, occurring with great constancy, though always scarce. Otherwise I have only found it in the *Uintacrinus* band in Hampshire and Kent and in the *Marsupites* band in Hampshire, and then only most exceptionally.

EXPLANATION OF PLATE VII.

FIG. 1. *Rhagasostoma Sussexiense*. Part of a branch. × 12.
,, 2. Ditto. Another part of the same branch. × 21.
,, 3. Ditto. The same specially lighted to show up the outlines of the zoœcia and avicularia.
,, 4. Ditto. Part of another branch. × 12.
,, 5. Ditto. Ditto. × 12.
,, 6. Ditto. Cross section through a branch. × 12.
,, 7. *R. palpigerum*. A fragment of a large zoarium from the *Uintacrinus* band, Margate. Nat. size.
,, 8. Ditto. Part of the same. × 12.
,, 9. Ditto. Ditto. × 21.
,, 10. Ditto. Part of a branch from the subzone of *Offaster pillula*, Seaford. × 12.

(*To be continued.*)

II.—The Classification of the Rocks of the Western Australian Goldfields.

By J. Allan Thomson, B.A., B.Sc., F.G.S.

Contents.

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II. Difficulties of Field Geology in Western Australia.
III. General Statement of the Problem, and Discussion of Previous Literature.
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V. Principles of Classification.
VI. Suggested Classification.
VII. Detailed Petrographical Studies.

I. Objects of this Paper.

THANKS to the descriptions published by visiting mining engineers and the more detailed work of the Geological Survey of the State, the general geological features of those parts of Western Australia in which mining is carried on are now well known. A surprising degree of uniformity of geological structure and mode of gold occurrence is revealed over an extent of country unparalleled elsewhere

in the world. And yet it is safe to assume that to the casual reader who has not visited the country the above publications present little else than a mass of bewildering detail.

"For reasons which can be readily understood, geological inquiry in Western Australia has up to the present consisted chiefly of a series of unconnected observations to the co-ordination of which we must look to the future." [1]

One reason for this, as outlined below, is the difficulty of field geology. A more important reason is the poor measure of comparative petrological study hitherto attempted, and the failure to use those principles of classification that have been worked out in areas of crystalline schists in Europe and America. The object of this paper is to give the main results obtained by the writer's petrological studies and to put forward as a working hypothesis a classification of the rocks which will serve as an introduction to a detailed discussion of each group in subsequent papers.

II. Difficulties of Field Geology in Western Australia.

The greater part of the State possesses an arid, if not a desert, climate, and shows, in consequence, surface features very different from those familiar in more humid regions. The most striking of these is the poor development of drainage systems in the whole region south and east of the Murchison River. On most maps there are no rivers shown within this area except in the immediate coastal districts, but large and small lakes are depicted in great profusion.[2] These lakes on inspection prove to be for the most part mere sandy depressions almost devoid of water except for a few weeks after a downpour of rain, and at other times containing only isolated pools of saline water. They are not, however, disconnected basins, for they pass at each end into dry valleys, and are clearly relicts of a former drainage system. Topographical maps of the heart of the country do not exist, so that it is at present impossible to reconstruct the earlier system and show how the lakes are connected. So flat are the present valley bottoms that it is difficult at times to say which way the present drainage runs.

The general surface of the country is remarkably monotonous. Low ridges and valleys follow one another like the waves of the sea. The valleys are rarely V-shaped or gorge-like, and most often show curves approaching those of the vertical section of a saucer. Only rarely does a dome-shaped mountain rise above the general level of the plateau.

There is a large body of evidence to show that the present surface has originated by the filling in of the valleys from one much more deeply dissected. Not only is this suggested everywhere by the cross-sections of the valleys and the alignment of the lake-basins, but it is proved in many localities by the mining of deep leads to some hundreds of feet below the surface of the present valley bottoms

[1] A. Gibb Maitland, Ann. Rep. Geol. Surv. Western Australia for 1910, Perth, 1911, p. 12.

[2] Cf. H. P. Woodward, "The Dry Lakes of Western Australia": Geol. Mag., Dec. IV, Vol. V, p. 363, 1897.

(e.g. Kanowna). The material filling the valleys is not, however, all or mostly of an alluvial nature. The sands which cover the lake-beds are largely wind-blown, and the same is true for much of the coarser material in the upper parts of the valleys. The whole area is swept by strong cyclonic winds, which convey the material broken by the usual agencies of desert erosion into the nearest hollows, while the finer sand is driven on to the lowest depressions, the lake-beds.

The arid climate has influenced the surface features in yet another way. The ground water level is deeper than is usual in more humid regions, and consequently oxidation of the rocks has proceeded to greater depths. This is especially the case in heavily mineralized belts, where the production of sulphuric acid from the sulphides has given the descending waters stronger powers of attack. The result is the rotting away of large bodies of rock and an increased efficacy of wind erosion. Side by side with the destruction of the solid rock has gone on a reconstruction of surface deposits of various kinds—laterites, surface quartzites, 'cement,' and 'cement gravel'. The laterites are predominatingly aluminous where resting on granite or gneiss, and ferruginous where resting on basic rocks. Owing to their hard nature, they now form the caps of many of the smaller hills and ridges. The 'cement' consists of oxidized rock fragments bound together by a calcareous matrix. The 'cement gravel' consists of rounded or ellipsoidal balls of reddish-white material, which when broken shows a concentric structure. It appears to consist mainly of calcite, but whether the balls have formed by accretion or by replacement is not quite certain. The 'cement gravel' is equally abundant on the sides of the ridges and in the valleys.

In consequence of the large areas occupied by the clastic materials filling the valleys, the deep-going oxidation of many of the rocks, and the widespread covering of surface deposits, the opportunities of examining the solid rocks are greatly curtailed. The rock, if it may be called rock that is at the same time hardest and least subject to oxidation, is jasper, and this forms the summits of many of the ridges. Other ridges are formed of practically unoxidized amphibolites or serpentines. Geological mapping is only possible by the acquisition of a local knowledge of the nature of the oxidized products of known rocks, and by inference from the surface deposits and the plant œcology. The study of rock contacts is seldom possible. Under all the circumstances it is no matter of surprise to find that our knowledge is practically confined to the immediate vicinity of the goldfields, where the underlying rocks are exposed by mining and prospecting operations.

III. General Statement of the Problem, and Discussion of Previous Literature.

With few exceptions the gold-bearing deposits are enclosed within basic schistose rocks, which are foliated in a general north-south direction and are highly inclined. The direction of foliation varies from N.E.–S.W. to N.W.–S.E. The schistose rocks alternate with, or enclose, lenticles of more massive rocks of similar composition.

In some districts there appear also to be sedimentary rocks associated with them. The whole complex is generally referred to as the 'Auriferous Series'. All these rocks occur in relatively narrow belts, separated by wider belts of granite and gneissic rocks, which when foliated possess the same general direction of foliation. All these belts possess a trend, so far as known, parallel to the foliation. Within the auriferous belts in almost every goldfield there are elongate lenticular bands of ferruginous and non-ferruginous jaspers and graphitic schists which also follow the same lines of trend. In most fields there are relatively unaltered intrusive rocks of various natures, viz. felsites, porphyries, porphyrites, and more basic rocks, which in some cases run parallel to, and in others cross, the direction of foliation.

A peculiar feature of many of the schistose rocks of the State is that when cut in depth by mining operations they are frequently stated to be quite massive.[1] In some cases this statement may be based on a faulty correlation: the shafts may pass through a band of schist into an unsheared phacoid of massive rock of similar constitution to the schists. It is, however, undoubtedly the case that many rocks which are apparently quite massive when mined, develop a latent schistosity after some years' exposure in mine dumps, and since this is so it is also reasonable to admit that this latent schistosity may be developed in the weathered parts near the surface. Dykes of sericite schist not unfrequently pass in depth into massive porphyries.

H. P. Woodward[2] in 1895[3] relegated these rocks to the Archæan, and divided them into granites, gneisses, and schists. He described the existence of six great belts crossing the country from sea to sea in a north–south direction. Commencing from the west coast near Perth, these belts are consecutively 'crystalline', 'crystalline', granite, western auriferous belt, granite, and eastern auriferous belt. The relationship of these belts to one another is not clearly indicated, but apparently he recognized that the granites are intrusive into the auriferous series, for he mentions that the western auriferous belt is broken and faulted by granite and diorite dykes. Subsequent observations have been very largely confined to the auriferous belts, and do not seem to have greatly modified Woodward's statement. A seventh belt of gneiss-granite has, however, been recognized on the eastern boundary of the Coolgardie–Kalgoorlie belt by Gibson.[4] A map of the State embodying the recently acquired knowledge is a great desideratum.

Much of the earlier literature relates to the Coolgardie Goldfield and its immediate surroundings, but is, unfortunately, of a very vague character. Coolgardie is situated on the contact zone between a granite on the west intrusive into the auriferous series in the east.

[1] Bull. xxii, pp. 15, 16, 1906. In this and subsequent references 'Bull.' stands for Bulletin of the Geological Survey of Western Australia.

[2] *Mining Handbook to the Colony of Western Australia*, Perth, by Authority, 1895, pp. 37, 38.

[3] The writer has not had access to Government publications prior to 1894.

[4] C. G. Gibson, Bull. xxiv, pp. 29, 30, 1906, and Bull. xxxvii, p. 23, 1909.

The granite along its margin is distinctly gneissose, while the result of contact alteration has been to reconstitute the basic rocks into well-foliated schists. Göczel[1] and many other observers supposed the granite to be a basal Archæan series on which the younger auriferous series was deposited as lavas and tuffs. Chewings[2] in 1896 and Blatchford[3] in 1899 clearly recognized the intrusive nature of the granite, and since that time granites intrusive into the auriferous series have been recognized over the whole length and breadth of the State. But at the same time the distinction between these granites and older gneisses has not always been held in view. Each of the main rock-series will now be briefly reviewed.

Gneisses.—The gneisses have not hitherto received any petrographical or chemical study. Their presence is noted in the Northampton Lead and Copper Field by A. Gibb Maitland.[4] The rocks are briefly described as "granites, gneisses, mica schists and quartz schists, etc., intersected by veins and masses of pegmatite".

"Sheeted zones of micaceous and garnetiferous schist and of garnetiferous gneiss stand out in bold relief with a general north-west and south-east trend." Maitland at one time believed the oldest rocks of the Pilbara District to be "granites and gneisses which form the platform upon which the oldest formations were laid down, and which everywhere underlie the plain extending from Port Hedland to Doolena Gorge on the Shaw River".[5] In a later publication, however, he concludes that the granite and gneisses are everywhere intrusive into the greenstones and associated beds,[6] so that it is doubtful whether any basal gneisses outcrop in the Pilbara District.

H. P. Woodward has described the occurrence of a series of gneisses, mica-schists, sericite schists, and quartzites in the Menzies Goldfield, but does not indicate very clearly whether he regards these rocks as older than, contemporaneous with, or younger than the amphibolites of the auriferous series.[7]

The Greenbushes Tinfield appears to be the chief mining area where pre-granitic gneisses and greenstones exist side by side, but again their relationship to one another is not clearly indicated. Woodward[8] describes the 'Crystalline Series' as consisting of gneisses merging in places into dark-coloured mica-schists, and intersected by dykes of albite-pegmatite, and basic rocks consisting of highly weathered hornblende and mica-schists, penetrated by dykes of highly foliated granite which are in turn penetrated by pegmatites. Dykes of bronzite-diabase intersect both gneisses and basic schists, but their relationship to the pegmatites is doubtful.

Numerous references to gneiss and gneissic granites in the Gascoyne, Ashburton, and West Pilbara Goldfields are made by Maitland,[9] but none of these are sufficiently definite for our present purpose. It

[1] G. Göczel, Interim Report, Dept. of Mines, W.A., for half-year ending June 30, 1894, pp. 18–23, Perth, 1894.
[2] C. Chewings, Proc. Roy. Col. Inst., London, vol. xxvii, pp. 263–371, 1896.
[3] Torrington Blatchford, Bull. iii, p. 20, 1899.
[4] Bull. ix, p. 9, 1903.
[5] Bull. xv, p. 10, 1904.
[6] Bull. xxiii, pp. 79, 80, 1906.
[7] Bull. xxii, pp. 14–16, 1906.
[8] Bull. xxxii, pp. 26–30, 1908.
[9] Bull. xxxiii, 1909.

can hardly be doubted, however, from the numerous references to extensive tracts of gneiss and gneissic granites outside the actual mining fields of the State that there is a fundamental system of Archæan gneisses similar to that of most other parts of the world, and probably of earlier age than the auriferous series. Seeing that so many of the granites are known to be intrusive into the auriferous series, it is remarkable that the distinction between newer granites and older gneisses has not been more clearly held in view by the officers of the Geological Survey of the State,[1] particularly as the former are intimately connected with the gold occurrences, and the latter, except where intruded by later granites, are free of all economic minerals.

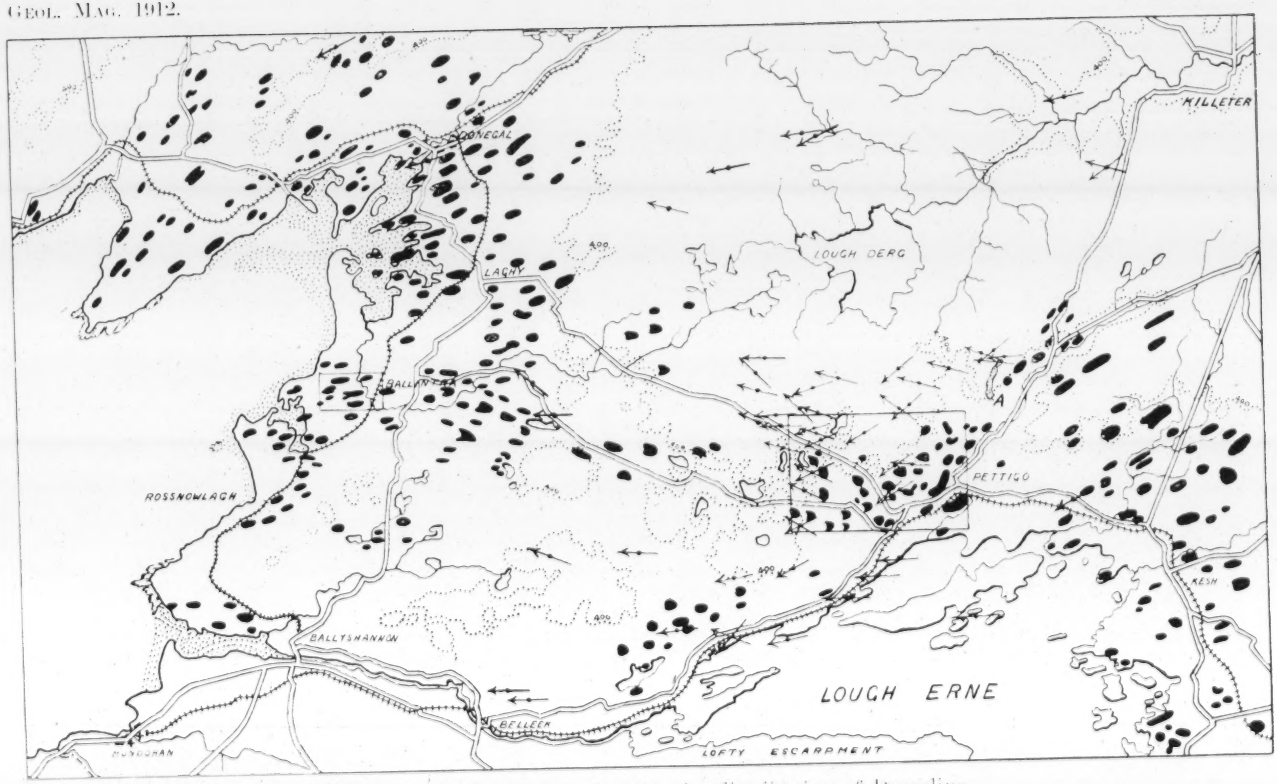
The Auriferous Series.—The rocks of this series are wonderfully uniform both in original petrological nature and in their present state of alteration over the whole State, and it is a perfectly justifiable assumption to regard them as of similar age. A large series of reliable chemical analyses has been made of them, but the accompanying petrological study has been very meagre, and vitiated by a lack of comparative studies. In most of the Bulletins of the Geological Survey it is briefly stated that the rocks are of the general type common to the goldfields of the State, and they are divided into massive and foliated varieties, and again into coarse-grained and fine-grained. Excellent petrological studies were carried out by Vogelsang[2] in 1897, and he showed that some at least of the amphibolites had originated from 'diabases'. Yet in spite of this and of the numerous analyses, the opinion is still occasionally put forward that the series may be of sedimentary origin. Vogelsang has, however, generally been followed by Simpson and Gibson, who have described more massive varieties as epidiorite, diorite, and amphibolites after 'diabase' and pyroxenite, and chloritic and sideritic rocks derived from amphibolite. No attempt has been made, except in Kalgoorlie, to map the various members of the series separately. It is greatly to be hoped, now that a petrologist has been added to the staff of the survey, that this will be attempted in all the principal goldfields, for otherwise the geological maps produced are practically valueless to the mining community.

The banded jaspers or 'ferruginous quartzites' which penetrate the amphibolites and hornblende schists of the auriferous series are generally admitted to be of the nature of lode formations or bands of highly replaced rocks. That they are anterior to the main deposition of the gold is also generally recognized.

The Granites and accompanying Dykes.—The granites generally form the boundaries of the auriferous series, and have seldom, therefore, been completely mapped. The smaller intrusions appear to be boss-shaped, while the larger ones are aligned in N.–S. bands. At the junction the auriferous series is almost invariably represented by well-foliated hornblende schists, whose foliation is parallel to the line

[1] Witness the practice of depicting granites known to be intrusive as 'Gn.' on the geological maps.

[2] K. Schneisser and K. Vogelsang, *Die Goldfelder Australasiens.* English translation, *The Goldfields of Australasia*, H. Louis, London, 1898.



Map of South Donegal showing the distribution of Drumlins.

of junction. That the granite has exercised a distinct contact action on the auriferous series is not generally recognized. The accompanying dykes are sometimes considered to be a later series, where they cut both the granites and the hornblende schists, but this, of course, is not a necessary assumption, for practically all granites are cut by dykes belonging to the same general series of intrusions. The granites have received a little petrographical treatment, but no classification of them into groups has been attempted. The accompanying dykes consist of fine-grained granite, granite porphyry, quartz porphyry, and 'felsite'. For the most part they follow the direction of foliation or are slightly oblique to it.

Granites of more than one age are occasionally recognized in the same field. Thus, near Mt. Percy in the Edjudina District, North Coolgardie Goldfield, Maitland describes a foliated granite (apparently intrusive into greenstone) and a later unfoliated granite.[1] In the North Murchison Goldfield, also, Gibson considers the granites of two ages, a younger undoubtedly newer than the greenstones, and an older of doubtful age.[2] In the Stannum Group of the Woodgina Tinfield, Pilbara Goldfield, Maitland recognizes an area of intrusive porphyry which is of later date than the greenstones and older than the granite and pegmatite veins.[3]

The close association between the intrusion of the granites and the deposition of the gold has been frequently, if not very clearly, indicated. The majority of the smaller goldfields are situated within the contact aureole of the granites, and many reefs are directly associated with dykes of 'felsite'. In a few fields the gold deposits are found within the granite itself. In other cases it is found that the deposits are intersected by dykes of acid rock.[4] The close association of tin and tantalum with albite-pegmatite is very clear.

(*To be concluded in our next Number.*)

III.—The Drumlin Topography of South Donegal.

By W. B. Wright, B.A., F.G.S.

PLATES VIII AND IX.

(The observations relating to the Pettigo area are communicated with the permission of the Director of the Geological Survey of Ireland.)

MOST people who have lived in strongly glaciated countries are familiar with the topographic features known as drumlins. They are more or less elongated hills of boulder-clay with their long axes parallel to the direction of ice-motion. The literature dealing with them is extensive, but for the most part rather unsatisfactory. Their mode of formation is entirely a matter of speculation and is likely to remain so. There is every reason to believe they are deep-seated products of the ice, so that observation of the process in modern ice-sheets is impossible. The only available means of getting at the

[1] Bull. xi, p. 30, 1903.
[2] Bull. xiv, p. 13, 1904.
[3] Bull. xxiii, p. 61, 1906.
[4] Gibson, Bull. xii, p. 11, 1904.

truth is by careful observation of the peculiarities of form and structure exhibited by these features in the areas where they are most characteristically developed.

Two such areas occur in the south of the county of Donegal in the north-west of Ireland, and were examined by the writer in the summer of 1910. They are both lowland districts formed of Carboniferous rocks, the first lying around the village of Pettigo, north of Lough Erne, and the second around the towns of Donegal and Ballintra. These areas are separated by a ridge of high moorland formed of metamorphic rocks and indicated by the course of the 400 foot contour shown on the map on Plate VIII. Such striæ as have been recorded in the district are also indicated on this map, and it will be seen that their direction corresponds very well with that of the adjoining drumlins.

In the district lying south-east of the moorland there are several rather distinct types of drumlin topography. To the north-east of Pettigo elongated hills occur with axes trending south-west. Some of these are composed entirely of drift, but others appear to be moulded on solid cores of rock, and in general in this area it is difficult to pick out the solid features from those due entirely to deposition. The

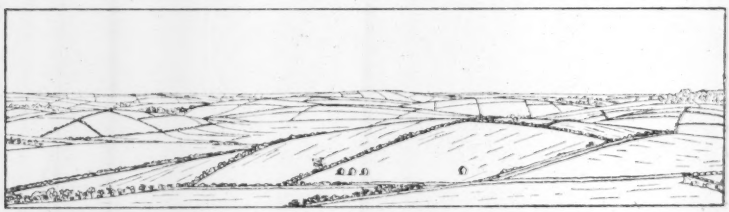


FIG. 1. View looking south-east from Carn Upper, near Pettigo, co. Donegal, across the direction of ice-motion. Gently domed drumlins of shortly oval outline.

country is deeply grooved and ridged in the direction of the ice-motion, which, there is every reason to believe, was just here more constant in its trend than further south-west. Such undoubted drumlins as occur are elongated and of the form most aptly described as hog-backed. Occasionally they show a tendency to develop a crested form similar to that of the drumlins of the Ballintra district to be described below. Immediately around Pettigo the predominant form of ground-plan is a short oval, and the tops of the hills are gently domed without any trace of a central ridge or crest. In Fig. 1 an attempt is made to portray this type of drumlin topography, and the contours on the east of the map in Fig. 2 also show well the character of a number of drumlins of this type. Further west in the neighbourhood of Carntressy and Belalt a third type of topography is in evidence. The drumlins here, like those of Pettigo, are subdued and gently domed in profile, but in ground-plan they take on most remarkable triangular and crescentic forms, which are well shown by the contours in Fig. 2. As the striæ in this area prove two directions of ice-motion, and as the sides of the triangles and the horns of the crescents are parallel to these two directions, one is irresistibly forced to the conclusion that

the form of these drumlins is the result of a change in the direction of the ice-flow. There is a certain similarity to the crescentic sandhills known as barkhanes, the concave sides of which face away from the prevalent winds.

In the case of these sandhills, however, there seems to be no necessity for any change in the direction of the wind, the cusps being built up by the natural creep of the sand round the flanks rather than over the crest. This flanking action, though no doubt occurring to a slight extent in the case of ice-motion, is not likely to have any powerful effect. Moreover, there certainly seems in the present case to be a distinct connexion with change in the direction of flow.[1]

If now we cross over to the second district, which lies to the north-west of the metamorphic moorland, in the neighbourhood of Ballintra, Laghy, and Donegal, we find quite a different type of topography.

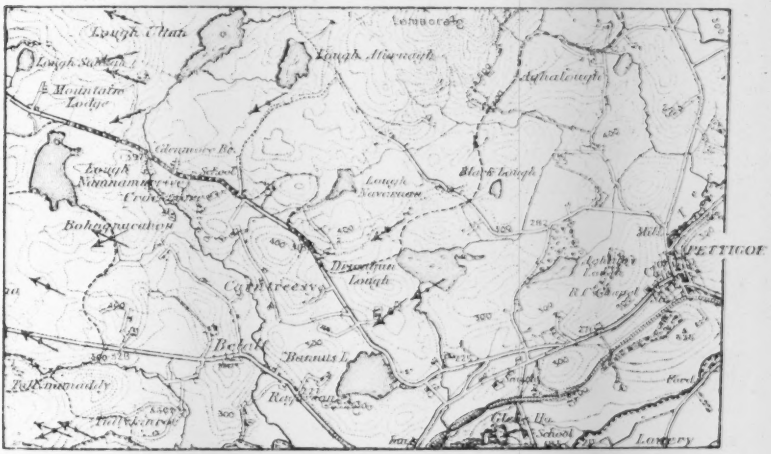


FIG. 2. Map of the district west of Pettigo, with contours every 25 feet to show the triangular and crescentic drumlins and the accompanying striæ indicating two directions of ice-motion. The heavy broken line marks the boundary of the Boulder-clay. Scale one mile to an inch. Reproduced with modifications from the Ordnance Survey Maps by permission of the Controller of H.M. Stationery Office.

Here the great majority of the drumlins are of hog-backed form and distinctly crested. An attempt is made in Fig. 3 to indicate the character of the country. The drumlin which stands out prominently in the centre of the picture is in every respect a perfect example of the class of hill which abounds in this district. Fig. 4 gives a more oblique view of the same class of drumlin. In both these sketches the undulating or serrated character of the crest is shown, and this is also well brought out in Pl. IX, Fig. 2. A curious feature is the intermixture of drumlins of other types. Thus Fig. 4 shows in the middle of the picture a small drumlin of the well known half-cigar

[1] See Vaughan Cornish, "On the Formation of Sand-dunes": Geogr. Journ., vol. ix, p. 290, 1897.

shape, without any marked crest and with an even unserrated profile. In the foreground on the right of Figs. 3 and 4 and also in the distance can be seen drumlins of gently domed outline without even a trace of a crest. Portion of the area depicted in Fig. 4 is shown as a contour map on the scale of 3 inches to a mile in Fig. 5. The drumlins numbered 1 to 5 in Fig. 4 bear corresponding numbers in the map. The contours, being at intervals of 25 feet, bring out the form of the ground with admirable precision. They show distinctly the narrowness of the crest and its serrated character, and make very apparent another peculiarity of certain of these drumlins, namely the forked outline at the downstream end. This forking is by no means a universal character, but a tendency to its development has been noticed in several parts of the Donegal and Ballintra area. Analogy with the crescentic drumlins to the west of Pettigo suggests that it is due to slight oscillation of the ice-motion.

Some cuttings on the Donegal and Ballyshannon Light Railway display very clearly the composition and structure of the drumlins of this area. The main mass of the hill is composed of stiff compact boulder-clay, but the upper 5 feet more or less is always relatively

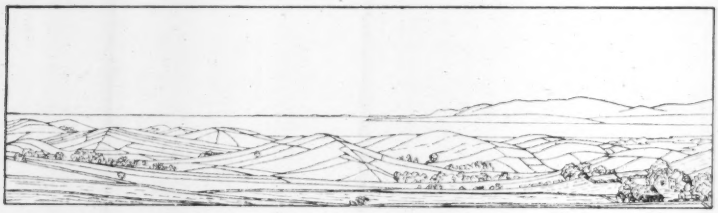


FIG. 3. View of drumlin topography looking west from Trumman, one mile south of Laghy, co. Donegal. The drumlins are viewed from the upstream ends. Both rounded and crested types come within the field of view. Donegal Bay and St. John's Point are seen in the distance.

loose and loamy. The junction between this upper boulder-clay and the compact till is generally fairly well defined. Pl. IX, Fig. 3, shows the top of a railway-cutting through the end of one of the drumlins, in which the line between the upper and lower boulder-clay is marked by calcareous oozings due to the escape of water along the junction. It is not unlikely that the upper boulder-clay is englacial material let down on the surface during the decay of the ice, and so never compacted by the ice-motion.

On first visiting the Ballintra district I was under the impression that the crested nature of the drumlins might be due to landslipping, and I was encouraged in this belief by observing an obvious recent landslip on the slope of one of these drumlins near Rossnowlagh. Landslips, however, possess as a general rule well marked and easily recognizable features, and these I have not observed in connexion with any other drumlins in the district. Mr. Hallissy has suggested to me a much better explanation in soil creep, which would naturally be at a maximum on the steep side slopes, and almost negligible along the median line. Such action might in time lower the slopes and

leave the median line standing up in the form of a crest. It is difficult to understand, however, how this process could produce a crest on one drumlin and leave another close by quite unaffected, as is often the case. I have therefore come to the conclusion that this feature is original and that the form of the drumlins is approximately the same as when they were first abandoned by the ice.

The mere occurrence of a crest gives ground for presuming that, in the building up of the drumlins, material is deposited mainly along the median line, and subsequently distributed down the slopes by the ice-motion. Its uneven serrated form is also in favour of this explanation as opposed to any process of ice-erosion or ice-moulding. The fact that crested and uncrested drumlins occur in the same area side by side is of considerable significance. It is explained by supposing that in the case of the crested drumlins deposition of material continued until the final exposure of the drumlin or until the ice became stagnant, while in the case of the uncrested drumlins deposition ceased before the ice came to rest, so that the subsequent ice-motion imparted a rounded outline to the top of the drumlin.

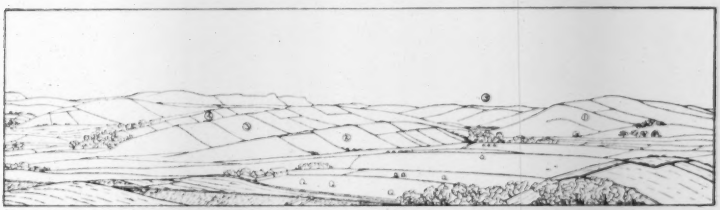


FIG. 4. View looking W.S.W. from a point one mile north of Ballintra showing several types of drumlin, the most numerous and typical having serrated crests. In the centre of the picture is a small drumlin of half-cigar form, and in the foreground on the right another of rounded form. Ben Bulben in the distance. The contours of the numbered drumlins are shown in Fig. 5.

Throughout the district examined there seems to be a well marked prevalence of drumlins of elongated ground-plan in areas where there is reason to suppose the fluctuation of ice-motion was least. It must be admitted, however, that the number of striæ recorded in these areas is not sufficiently great to prove the absence of variation in direction. It can, however, be very definitely stated that in the one area, that lying west of Pettigo, where a distinct oscillation has been proved, the drumlins assume shortly oval, rounded, triangular, and crescentic forms. The reason for this fluctuation is to be found in the existence of fairly lofty hills to the south of Lough Derg. During the later stages of the glaciation these formed a barrier to the ice coming from the north-east, so that the flows converging on the head of Lough Erne from the east and south-east obtained the upper hand. This consideration of the local conditions assures us therefore that in this area of conflicting striæ the north-westerly motion was later than the south-westerly. Moreover, there is a fair presumption that in the eastern part of this area the change in direction was less abrupt than

in the western part which lies right in the lee of the hills. The eastern part has rounded drumlins, the western crescentic and triangular drumlins. It is suggested that gradual change of direction produces the rounded forms and sudden change the triangular and crescentic forms.

Further, there is a complete absence of cresting in this area of oscillation. The drumlins are smoothly domed and often subdued in profile. Change in the direction of the ice-motion seems to prevent the production or else the preservation of crests.

The ideas discussed above as arising out of the evidence cited may be summarized in the following propositions, which, however, are not regarded as proved, but are only put forward tentatively in order that their applicability to other areas may be tested.

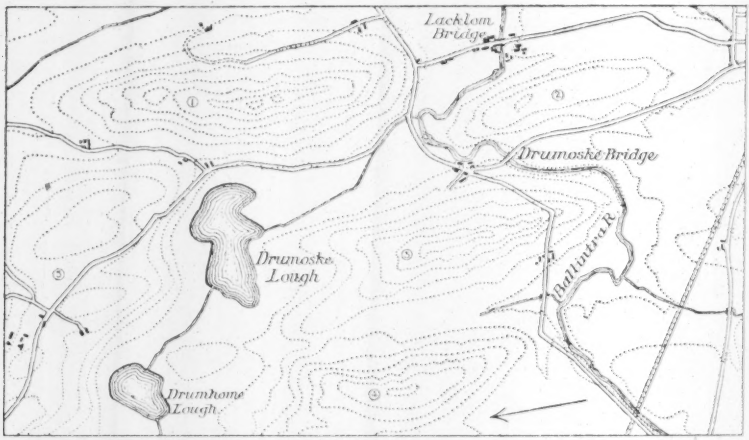


FIG. 5. Contour map of the drumlin topography west of Ballintra, co. Donegal. The drumlins, numbered 1 to 5, are marked with corresponding numbers in Fig. 4. Nos. 1, 3, and 4 are typically crested drumlins with serrated profile. They are also forked at the downstream end. No. 2 is of half-cigar form. Contours every 25 feet, taken from the Ordnance Survey Maps. Scale 3 inches = 1 mile. The arrow shows the direction of ice-motion. Reproduced by permission of the Controller of H.M. Stationery Office.

1. Drumlins are built up by the addition of material mainly along the median line.

2. If this addition of material is continued until the complete withdrawal of the ice or until the cessation of the ice-motion, then the drumlin is left with a crest.

3. If on the other hand the addition of material ceases before the ice-motion, then the latter imparts to the drumlin a smoothly rounded outline.

4. In areas where the ice-motion is constant in direction the resulting drumlins are elongated.

5. If on the other hand the direction of ice-motion is continually changing, the resulting drumlins are shortly oval.

Fig. 1

Fig. 2

Fig. 3

Drumlins of South Donegal.

6. In cases where there is a relatively sudden change of motion the drumlins tend to assume triangular, crescentic, and forked outlines.

DESCRIPTION OF PLATES VIII AND IX.

Plate VIII.

Sketch-map of South Donegal showing the glaciation. The drumlins, shown in black, are inserted to some extent from personal knowledge of the ground, but are also largely deduced from the contours of the 1 inch and 6 inch Ordnance Maps combined with the original drift-mapping of the Geological Survey of Ireland. The areas treated in more detail in other maps are outlined. At the point marked A there is a small latero-terminal moraine on the hillside. Scale ½ inch to the mile. Reproduced with modifications by permission of the Controller of H.M. Stationery Office.

Plate IX.

Fig. 1. View of drumlin topography from the Roman Catholic Chapel, Ballintra, looking west in the direction of the ice-motion.

Fig. 2. Drumlin with serrated crest viewed obliquely from the stoss end, Drumnacoil, near Bridgetown, one mile north of Ballintra.

Fig. 3. Railway-cutting near Rossnowlagh Station. Section through drumlin showing upper and lower boulder-clay. The line of junction is indicated by the calcareous oozings due to water percolating along the upper surface of the compact lower till.

IV.—The Birth of an Island near the Coast of Trinidad.

By T. O. Bosworth, B.A., B.Sc., F.G.S.

As some erroneous statements have appeared in the Press about this interesting event, it seems advisable that the true facts should be placed on record.

Geological Character of the District.

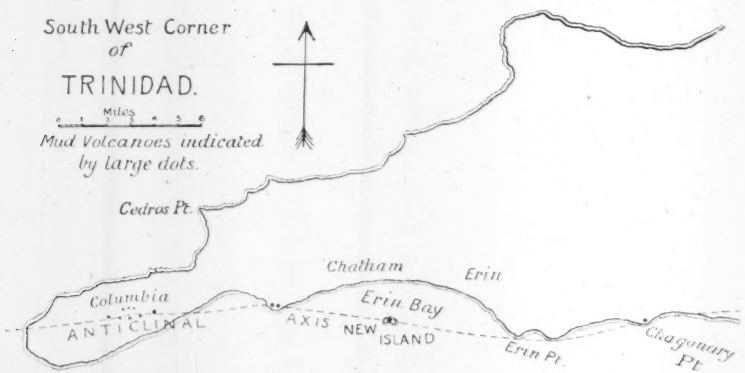
The shape of the Island of Trinidad is approximately rectangular and conforms to its simple geological structure. Along the north side is a mountain range formed of metamorphic rocks, but elsewhere folded Tertiary (and occasionally Cretaceous) strata are at the surface.

The anticlinal axes are some two or three miles apart, and have parallel sinuous trends with a general east and west direction. They have been mapped over a large part of the island by Mr. E. H. Cunningham Craig, F.G.S., for the Government, and have been further mapped and studied in detail by the writer during the past year, some seven or eight distinct anticlines being now known. Some of these anticlines are found to die out in the course of a few miles, but two or three folds of greater importance are remarkably persistent, and one at least of these is now proved to be continuous from east to west right across the island and has been mapped throughout practically its whole length—a distance of over sixty miles. This anticline is nearly parallel with and close to the south coast of Trinidad, often being well exposed on the foreshore, but by reason of its sinuosities and the irregularities of the coastline the axis of the fold, though generally on dry land, is in some parts of its course under the sea. Indeed, where it crosses Erin Bay it must be nearly two miles from the shore. It is in this bay that the new island has been formed, directly on the line of the anticline.

The Tertiary strata of Trinidad consist of clays and lenticular, current-bedded sandstones, the whole sequence displaying remarkable lateral variation. Along the anticlines, which generally are sharp and very steep, petroleum has accumulated where the conditions are favourable, and its presence is manifested by escaping gas, seepages of oil, and by extensive surface spreads of pitch. In some places occur beds of clay-shale, which have become burnt (probably at depth) into red 'brick' by the spontaneous combustion of the hydrocarbons contained.

Neighbouring Mud Volcanoes.

Along the Southern Anticline 'mud volcanoes' are a characteristic feature. These are commonly cones of mud with a crater at the top from which issue gas, oil, salt water, and mud. The majority are only a few feet high, but some are much larger. Others again are but slightly conical, and appear as mud springs sometimes several hundred feet across. About forty mud volcanoes and groups of volcanoes are



known to the writer on this one anticline, and as a rule they are so truly situated on the crest that where rock exposures fail they have afforded invaluable evidence for mapping the anticline.

One of the largest of these volcanoes is at Chagonary Point, about 7½ miles east of the new island. Mr. Cunningham Craig says of it:[1] "The circular area of barren mud marking the crater is some 80 yards across, and a flow of mud has descended to the beach a distance of 250 yards. Trees one foot in diameter have been broken and the upper part thrown away from the centre of the outburst. Blocks of rocks up to 15 inches in diameter have been brought up from beneath the surface and scattered about the mud crater. They consist of ironstone nodules, nodules and crystalline groups of pyrites, Cretaceous pebbles, coarse Tertiary grit, and fine pale sandstone with plant remains and calcite vein-stuff. A bituminous odour is noticed on all the porous ejected fragments and in fact a smell of petroleum pervades the whole locality."

Another large one is the Columbia volcano near Cedros, about ten

[1] Council paper No. 119, Trinidad, 1905.

miles west of the new island, which has been described by Mr. A. Beeby Thompson, M.I.Mech.E., F.G.S.,[1] as follows:—

"Several acres of ground were quite bare of vegetation and strewn with newly ejected argillaceous mud mixed with occasional fragments of iron pyrites, etc. All over the area inflammable gas was oozing up through numberless fissures with a hissing sound, and towards the centre was a crater of stiff pasty clay kept in agitation and puddled by the evolution of immense volumes of gas. This central crater had a diameter of about 60 to 80 feet, and the discharged mud was so soft around that close approach was unsafe. At intervals of a few minutes violent eruptions occurred, accompanied by the evolution of enormous volumes of gas, causing the ejection of many tons of clay to a height of 20 to 30 feet. Before each explosion the ground for a radius of 50 feet heaved and quivered, and the central portion rose slowly until it burst, causing the expulsion of masses of clay, the bulk of which fell back into the crater in great blocks."

The New Island.

The writer left the locality about three months before the birth of the new island, and the following account of it is from a letter written by Mr. E. C. Buck, A.M.I.C.E., A.M.I.M.E.:—

"At 5.30 p.m. on the 4th inst., at a point between Chatham and Erin and about 1½ miles to sea, a tremendous explosion took place accompanied by an enormous column of fire, and mud and stones were thrown out to such an extent that an island having an area of about 2½ acres was formed in a few minutes. The highest portion of the island is about 14 feet above high water level.

"On the morning of the 5th inst. the Governor rang me up and asked me to go with him to discover this island. We started at 8.30 a.m. and sighted the island at 4 p.m. From my observations I find that the island is situated at a point 1¾ miles from Chatham and 3½ miles from Erin, and on a line passing through Points Islot and Erin. I had the pleasure of being the first to land, and it was a rather risky proceeding as the mud and clay was still very pulpy and under the crust the mud was exceedingly hot. However, I effected a landing and the others soon followed. Two craters were discovered near the northern end of the island, one being very active in ejecting. The shape of the island is an ellipse with the major axis running north-west to south-east. I obtained some good examples of the strata thrown up."

"By chance the explosion was observed by Mr. A. C. Veatch, a geologist, who was on board ship some miles away. His notice was suddenly attracted by a great flame that shot up into the sky at dusk. With the first puff the flame rose as a brilliant mushroom-shaped mass, which immediately changed its form to a straight jet of fire that must have risen to a height of at least a thousand feet. No noise whatever, preceding or accompanying the fire, was heard by this observer, who was fourteen miles away. The fire disappeared below the horizon in about five minutes, leaving a cloud of smoke that drifted away."[2]

[1] *Petroleum Mining*, 1910. [2] From the *Morning Post*, January 5, 1912.

And in another letter from Mr. E. C. Buck, dated January 22, 1912: "A sandy beach of considerable extent has now formed round the island, and the craters have diminished to the ordinary dimensions of the mud volcanoes on land."

The specimens have been examined by Mr. Beeby Thompson, sen., F.C.S., F.G.S., and by the writer.

The main bulk of the erupted material is bluish clay mud with an oily smell and quite similar to that produced by neighbouring mud volcanoes.

The rock fragments consist of sandstone, clay-shale, burnt clay, pyrites, etc. The burnt clay is a hard red 'brick' like that occurring in other localities as mentioned above, but as no bed of such rock is found near here it seems probable that the burning has been performed during this eruption.

The pyrites is in bright crystals and some of the rock fragments are highly charged with it. There are also aggregations of it forming nuggets several inches across. This mineral is often conspicuous in the ejecta of mud volcanoes, and is interesting in view of the common association of sulphurous waters with petroleum and the frequent presence of sulphur in the oil.

From the crater were taken some fragments of a fine argillaceous breccia. It is calcareous and contains, besides pyrites, some small shells and Foraminifera. This rock was analysed by Mr. Beeby Thompson, who found in the matrix a high proportion of calcium phosphate and ferrous carbonate. It is in fact a kind of clay ironstone. At the surface no exposure of this bed has been observed.

It is probable that previous eruptions have occurred on the site of the new island, for it is apparently coincident with a mound on the sea-floor which is shown on the Admiralty charts. Soundings have proved a depth of only 1 fathom at this spot, though it was surrounded by water 3 fathoms deep.

The facts which have been described above can leave little room for doubt as to the origin of the new island.

Analogous Events in Borneo and Burma.

Two similar instances may be cited for comparison which are described by Mr. A. Beeby Thompson in his work on *Petroleum Mining*—[1]

"On 21st December, 1897, the disturbance occasioned by an earthquake led to the formation of a great mud volcano beneath the sea off the southern point of the Klias Peninsula of Borneo, when sufficient argillaceous material was ejected to form a new island 750 feet long, 420 feet wide, and 20 feet above sea-level. The eruption occurred on the crest of a well-known anticline with steep sides, on which petroleum gas exudations had frequently been observed in other localities, where it crossed the land.

"Probably one of the greatest mud volcanoes on record was formed off the Burma coast on 15th December, 1907, when sufficient material was ejected to form an island 1,200 feet long, 600 feet wide, and

[1] *Petroleum Mining*, 1910, pp. 102–3.

20 feet above sea-level, upon which a landing was effected by the officers of a British marine survey ship shortly after the eruption, when the mud still indicated a temperature of 148 deg. Fahr. a few feet below the surface."

V.—A Note on the Carboniferous Limestone of the Crich Inlier.

By H. C. Sargent, F.G.S.

I CHANCED a few weeks ago to see, for the first time, a short paper by Mr. J. Wilfrid Jackson, F.G.S., in the Geological Magazine (Dec. V, Vol. V, p. 266) on "Mottled Foraminiferous Limestone in West and North Lancashire". In that paper Mr. Jackson thus describes specimens of mottled limestone from Silverdale: "The matrix is light-coloured and fine-grained, with irregularly shaped patches (? nodules) of a fine-grained dark-coloured limestone. The patches have no definite shape, being mostly very uneven in size, some of them being long cylindrical bodies with irregular contours."

Mr. Jackson writes with special reference to a paper by Messrs. Barnes & Holroyd, in which they describe limestone of the same character from North Derbyshire,[1] and similar mottled beds may also be seen in the quarries near Crich in the southern part of the county.

Messrs. Barnes & Holroyd, in the paper referred to, show, as I think, conclusively that the difference in colour between the dark and light portions is due to a larger proportion of carbonaceous matter in the former than in the latter. They go on, however, to say that this "is caused by the absence in the light part of the remains of foraminiferal life, while in the dark we have abundant life remains, and these in a most perfect state of preservation". On this point Mr. Jackson states as follows: "In the Silverdale specimens, so far as I have made out, foraminifera are almost as numerous in the light portion of the rock as in the dark,"[2] and this observation agrees with my own examination of thin slices prepared from the Crich rock.

Messrs. Barnes & Holroyd are further of opinion "that the dark and light are not the same limestone, but that the dark has been removed from its original place of deposition and intermingled and cemented into the lighter matrix".[3] They consider that this process has been effected by volcanic activity. "Given that these outbursts of volcanic activity were preceded by the usual earth shocks and sea disturbances, and the neighbouring presence of calcareous beds of dark foraminiferal mud, we have all the conditions necessary for the turning up from the sea bottom, and consequent removal to another area of the dark parts, together with the redeposition and consolidation to produce the peculiar mottlings."[4] Whereupon Mr. Jackson naturally inquires whether these effects of volcanic activity in

[1] "On the Mottled Carboniferous Limestone of Derbyshire": Trans. Manch. Geol. Soc., vol. xxvi, p. 561.

[2] Loc. cit. [3] Loc. cit. [4] Ibid.

Derbyshire were felt "so far away as Grange and Silverdale". I venture to think that the presence of this dark limestone in a lighter matrix may be explained in a much simpler way.

In the Crich area we have limestone of every shade of colour from white, through grey, light blue and dark blue, to black. There is generally a clear line of demarcation between each shade of colour, and this frequently takes the form of an impervious clay-band. The mottled beds are also present, and they invariably, so far as my observation goes, form passage beds between lighter and darker shades of the rock in places where there are no clay-bands to delimit the areas of the two shades. These mottled beds are called 'curly' by the quarrymen, in allusion to their somewhat irregular fracture, which frequently follows the boundary-lines of the dark patches, as Messrs. Barnes & Holroyd state in their paper.

In Hilt's Quarry, Crich, where the mottled beds may best be studied, they occur on two horizons: (1) between beds of white and light-blue limestone, (2) between beds of light-blue and dark-blue limestone. In each case the two shades of the mottled or 'curly' rock are the same as those of the rock above and below respectively.

There can therefore, I think, be no doubt that the dark and the light of the mottled rock are the same limestone; in other words, that they were deposited contemporaneously.

The varying shades of colour in the limestone are due to varying proportions of carbonaceous or bituminous matter contained in it. The percentage of such matter in specimens collected in Hilt's Quarry ranges from 0·62 in the white to 2·02 in the black. (Analyses by Mr. Eric Sinkinson.)

The presence of this carbonaceous or bituminous matter in the limestone is difficult to explain satisfactorily in all circumstances, especially in view of its frequent impersistence horizontally. The matter is still under investigation, and I hope to have more to say about it before long. At present it seems probable that it may be of both original and secondary origin—original in regard to organisms embedded during deposition, secondary as the result of subsequent infiltration. Possibly the latter has had the wider effect.

Finally, I suggest that if the supply, whatever be its source, were insufficient to permeate fully the rock accessible to its influence, there would be a tendency, owing to the nature of the substance, for it to collect into oleaginous patches, of shape and size varying according to the supply available and the conditions of environment, such as capillary influences, degree of porosity, etc. This I believe to be the explanation of the mottled or 'curly' rock.

VI.—The occurrence of a Human Skeleton in Glacial Deposits at Ipswich.

By George Slater, F.G.S.

THE great interest excited by the recent announcement in the *Times* and elsewhere of the alleged discovery of a skeleton of "pre-Boulder-clay man" renders it desirable that the geological evidence should be carefully examined.

At a meeting of the Prehistoric Society of East Anglia, held at Ipswich, February 21, 1912, Mr. J. Reid Moir read a paper on "The occurrence of a Human Skeleton in a Glacial Deposit at Ipswich". The sand-pit from which the bones were obtained is worked by Messrs. Bolton & Laughlin, brickmakers, and is situated about a mile north of Ipswich, and west of the Henley Road near the Prospect Cottages. The bones were discovered on Friday, October 6, 1911, whilst workmen were engaged in removing some surface clay near the top of the eastern side of the pit in order to get at the underlying sand and gravel. The general section on this side of the pit is extremely unsatisfactory. Capping a considerable thickness of sand and gravel (the latter in places containing derived Jurassic material in the upper parts) is a bed of extremely weathered clay not more than 4 feet in maximum thickness including the top soil and turf, but only 2 feet thick in the sides of the trench where the bones were discovered, and of this 1 foot can only be described as soil. It is important to remember that the Boulder-clay thins off entirely near this point to the south-east, this fact being well shown on a geological map of the district recently made by Mr. P. G. H. Boswell, B.Sc., F.G.S., and Mr. I. Double, of Ipswich, the 6 inch ordnance maps of the district being used for the purpose.

The weathering of the clay has gone on to such an extent that only small scattered patches of unweathered chalky Boulder-clay occur. The decalcified clay is of a deep-brown colour, and is crowded with roots which often pass quite through the clay into the sands below. The result of this is that the free passage of water through the clay is easy and consequently infiltration has been excessive. Below the clay the underlying sands are deeply stained with iron oxide in places to over 1 foot, and beneath the stained portion is a fairly constant calcareous band.

It was only after the bones had been entirely removed to London that Mr. W. Whitaker, F.R.S., Dr. Marr, F.R.S., and myself were asked to report on the beds in the section and in the sides of the empty trench.

Mr. Whitaker, in the course of his report, said: "The pit is worked for sand and gravel, belonging to the glacial drift, and is just where Boulder-clay is marked on the geological survey map as coming above the sand. There is no doubt in my mind that the pit gives a junction-section of the Boulder-clay with the underlying sand and gravel. The skeleton was found at the eastern side of the pit at this junction. *The top earth was only some 3 feet thick*, and the process of weathering has gone to such an extent that perhaps no one seeing merely that one particular spot would say that Boulder-clay occurred, but there is unweathered Boulder-clay close by in the same sandy or loamy earth, and I can see no reason to differentiate one particular yard or so from its surroundings. I could see no signs of artificial disturbance of the soil, and was told that none had been seen during the excavation. Slipping seems out of the question." Referring to the fact that the bony cavity of the skull is filled with earth of *the same kind as that in which the skeleton was found*, he said: "I fail to understand how man could have lived at the time of the

commencement of the Boulder-clay, and I am in hopes that further excavation may throw more light on this strange occurrence."

Dr. John E. Marr, who visited the site after the skeleton was removed, reported that the clay resembled decalcified Boulder-clay, and had patches of unaltered clay here and there. It was very thin, and *he hesitated to pronounce any definite opinion.* He did not know how one would distinguish between Boulder-clay in situ and clay which had been derived from Boulder-clay at a somewhat higher level, which had flowed as the result of being waterlogged. Such flows were often seen on beaches below Boulder-clay cliffs, and they strongly resembled true Boulder-clay. He did not, however, suggest that the clay above the skeleton had that origin, but that personally he was unable to distinguish a thin mass of such a clay from true Boulder-clay. In the course of a further letter on the subject Dr. Marr said that he could see no difference between the decalcified Boulder-clay in the higher pit above the normal undecalcified Boulder-clay, and the decalcified clay above the skeleton. The slopes in the vicinity were very slight, but they might have been diminished by erosion, and it was possible that the clay might have been moved from another place.

According to the report in the *Times* the skull was filled with Boulder-clay. During the lecture Professor Keith referred to this point. With regard to the skull having becomed filled, Professor Keith remarked, that the material, which was *the same as the stratum in which the skull lay*, could only have been carried in by three agencies—water, roots, and worms—and he thought the last two might be excluded. They were driven to suppose that, when the skull came to rest, there existed a more moist or fluid condition of the stratum.

It will be seen from these reports that neither Mr. Whitaker nor Dr. Marr can be looked upon as very decided supporters of Mr. Moir's view. The very important point raised by Dr. Marr as to the effect of the slopes on erosion is crucial to the present matter. Both Mr. A. D. Hall, M.A., F.R.S., and Dr. Russell have shown in their investigations on soils that even a sedentary soil is never at rest, and that rain-wash is an important factor in soils even when the slopes are slight. In the present case the site of the discovery is on the side of a valley. The plateau to the east reaches a height of about 160 feet, half a mile to the east of the section; this gives a gradient of roughly fifty feet in half a mile. Between the plateau to the east and Norwich Road on the west, a distance of one mile, there is a drop of 100 feet or more. It is quite reasonable to conclude that the upper part at least of the clay in the section is the result of slow accumulations of rain-wash.

The calcareous band referred to in the sands beneath the clay is in the nature of a 'cemented pan', the rainfall being only sufficient to remove the calcareous matter from the clay down to a depth of three or four feet. Certainly such a bed is no sign of antiquity as such 'pans' are known to form quite rapidly. It is obvious that everything depends upon the evidence of those who saw the bones in situ.

Mr. Moir was informed of the discovery and his account of the

excavation is interesting. He at once went down to the pit where the discovery had been made, and found that a portion of a human skull attached to an almost complete cranial cast, had been recovered. The workmen pointed out that two bones were protruding from the spot where the skull had been derived, and *said it was arranged for the remainder of the skeleton to be dug up on the following day.* Recognizing the importance of having the disinterment properly and carefully observed, three gentlemen—Messrs. Woolnough, Canton, and Snell—accompanied him, and they afterwards drew up a short report of their observations. In this report of the digging out *on October 7*, they say:—"We all most carefully examined the section of decalcified Boulder-clay, *under which the bones lay*, before any digging commenced, and we are absolutely convinced that *no grave* had ever been dug on the spot before. This opinion was confirmed (1) by the *extreme hardness* of the *Boulder-clay*, which necessitated the continued use of picks in getting it up. (2) There was not the slightest sign of any mixing of the soils (such as would occur in an old grave), the Boulder-clay *resting normally on* the underlying glacial sand as it does in all sections known to us where the succession of the beds is the same. (3) That in the event of a grave having been dug in the past on this spot, it is hardly conceivable that we should have dug down in exactly the same place as the original diggers, and that therefore one side at least of their digging would be visible in the remaining section of Boulder-clay.[1] (4) *The extraordinary cast of decalcified Boulder-clay*, which completely filled the inside of the skull, we consider points to the conclusion that the clay was in a semi-fluid state at or since the time when the remains were embedded in it. We think it most unlikely that the clay in its present hard condition (a condition which has apparently been present since the last great extension of the glaciers) could work its way into any skull buried in it. (5) *The bones were lying partly embedded in glacial sand and partly in decalcified clay.* This sand showed most plainly the lines of stratification, and was quite conformable with that underlying it."

The report of these gentlemen says: "We all most carefully examined the section of decalcified Boulder-clay, *under which the bones lay . . .*" And yet in (5) "the bones were lying *partly embedded in glacial sand and partly in decalcified clay*".

During the lecture Professor Keith also referred to the same point. The right side of the skeleton, which lay in contact with the glacial sands, was much better preserved than the left, which was uppermost, and *embedded in the Boulder-clay*, and thus most subjected to the destructive effects of the roots of plants and the eroding action of the clay. The roots reached deeply in the glacial sands, and their effects were absolutely manifest on the skull and pelvis. The Boulder-clay (sandy, chalky loam) had also eaten into the bones, and all the soft spongy bone (feet, spine, etc.) was represented by dense clay in which minute fragments of the original bone could be detected. Thus, there was not a single complete bone recovered with the exception of the small bones of the right hand. By great

[1] See letter by Professor T. McKenny Hughes, F.R.S., on "Obliteration of Traces of Interment" (*infra*, p. 187).

good fortune the cavity of the skull must have been completely *filled at an early stage with the surrounding matrix*, and thus a complete cast of its interior had been preserved. A fragment of the frontal bone, sufficient to show the characters of the forehead, parts of both temporal bones, with the joints of the mandible and fragments of the parietal and occipital bones, were also present. The face and jaws were gone, but fortunately nine of the teeth were found.

At the close of the meeting, in answer to a question, the point was again referred to. Dr. Hossack pointed to the fact that many of the bones, not only soft ones, but others, had disappeared, but Professor Keith replied that this was *due to the position of the skeleton in the clay and sand*, the bones preserved being chiefly those from the sand.

The evidence as to the position of the bones seems to be unmistakable, they were found partly in the Boulder-clay and partly in the sand. It is difficult to understand how this could have occurred naturally under any circumstances. The sand was presumably deposited by running water, the Boulder-clay by moving ice, entirely different conditions obtaining at different times.

As to the theory that these remains may have been buried, Professor Keith remarked there were various pebbles and splinters of stone found immediately beneath certain parts of the skeleton, as if they might have rolled into the open grave, but in the deepest stratum of the Boulder-clay such stones were abundant and the question of burial must be left open. With regard to the signs of antiquity in the bones, he pointed out that the bones were not mineralized, but, on the contrary, were extremely light. The bony matter had exactly the appearance of chalk.

Much stress has been laid on the fact that those who saw the bones in situ saw no indication of a grave.[1] But we should not expect to see such indications considering the time which has probably elapsed since the death of the person whose skeleton was found. There is much general evidence on this point. Even comparatively recent graves, as seen at the cliffs near Dunwich, are difficult to trace.

In the Journal of the Suffolk Institute of Archæology, 1907, Miss Layard, F.L.S., in describing an Anglo-Saxon Cemetery, Hadleigh Road, Ipswich, presumably a Pagan cemetery of the sixth century (p. 6), says (p. 1): "On a first visit to the spot in January, 1906, I noticed human bones protruding from the side of the cutting, but as the skeleton had already partly been removed, nothing was found with it. The clean condition of the red crag in which the bones lay was sufficient proof that the burials were of very early date, as there was little trace of organic discolouration in the surrounding earth." The depth of these graves seems to have varied from about 2 to 4 feet, and apparently the only indications of graves were to be seen in the presence of bones and ornaments. In the present instance the bones were found about 3 feet below the surface.

All the evidence points to the probability that the man was buried in a narrow shallow grave, but there is no evidence as to when this took place; we can only label the skeleton "of doubtful age".

[1] See Professor T. McKenny Hughes' letter (*infra*, p. 187).

NOTICES OF MEMOIRS.

On the Fossil Flora of the Forest of Dean Coalfield (Gloucestershire), and the Relationships of the Coalfields of the West of England and South Wales. By E. A. Newell Arber, M.A., Sc.D., F.G.S., University Demonstrator in Palæobotany, Cambridge.

Reprinted from Proc. Roy. Soc. London, B 579, vol. 84, p. 543, 1912.

VERY little has been previously recorded of the flora of the Forest of Dean Coalfield, and in the present paper the results of a thorough examination of the flora, and of the vertical distribution of the plants in the three divisions of the productive measures of this coalfield, are discussed. In all forty-four species are described, none of which, however, are new to Britain, though some are rare plants elsewhere. The list of species is as follows:—

Equisetales.

Calamites varians, Sternb.; *C. ramosus*, Artis; *C. suckowi*, Brongn.; *C. undulatus* (?), Sternb.
Calamocladus equisetiformis (Schloth.).
Annularia radiata (?) (Brongn.); *A. stellata* (Schloth.); *A. galioides* (L. and H.); *A. sphenophylloides* (Zenker).
Calamostachys tuberculata (Sternb.).
Macrostachya infundibuliformis (Brongn.).

Sphenophyllales.

Sphenophyllum emarginatum, Brongn.; *S. majus* (Bronn).

Pteridospermeæ and Filicales.

Sphenopteris neuropteroides (Boulay); *S.* (*Renaultia*) *chærophylloides* (Brongn.).
Mariopteris muricata (Schloth.); *M. latifolia* (?) (Brongn.).
Neuropteris scheuchzeri, Hoffm.; *N. macrophylla*, Brongn.; *N. ovata*, Hoffm.; *N. rarinervis*, Bunb.; *N.* (*Cyclopteris*) *fimbriata*, Lesq.
Alethopteris aquilina (Schloth.); *A. grandini* (Brongn.); *A. davreuxi* (Brongn.).
Pecopteris miltoni (Artis); *P. polymorpha*, Brongn.; *P. arborescens* (?) (Schloth.); *P.* (*Dactylotheca*) *plumosa* (Artis).

Semina incertæ sedis.

Trigonocarpus noeggerathi (Sternb.).

Lycopodiales.

Lepidodendron lanceolatum, Lesq.; *L. aculeatum*, Sternb.; *L. wortheni*, Lesq.; *L. dichotomum*, Sternb.
Lepidophloios cf. *L. laricinus*, Sternb.
Lepidophyllum majus, Brongn.; *L. brevifolium*, Lesq.
Sigillaria lævigata, Brongn.; *S. elongata*, Brongn.; *S. rugosa*, Brongn.; *S. trigona*, Sternb.; *S. tessellata* (Sternb.); *S. brardi*, Brongn., var. *denudata* (Goepp.).

Cordaitales.

Cordaites angulosostriatus, Grand'Eury.

The floras of the three divisions of the productive measures in the Forest of Dean are compared, and it is found that they are practically identical. All three divisions belong to the palæobotanical horizon known as the Upper Coal Measures. It is shown that there is a marked agreement between the flora of the Forest of Dean and the Upper Coal

Measure floras of other British coalfields, though the following species which occur in the Forest have not previously been recorded from this horizon elsewhere :—

Annularia galioides (L. & H.).
Sphenophyllum majus (Bronn).
Mariopteris latifolia (?) (Brongn.).
Lepidodendron dichotomum, Sternb.
Sigillaria rugosa, Brongn. ; *S. trigona*, Sternb. ; *S. brardi*, Brongn., var. *denudata* (Goepp.).

The flora of the Forest of Dean is contrasted with those of the neighbouring coalfields. As compared with the Radstock flora, there is found to be a general agreement, though there are important differences in detail, which are more marked than those which exist between the known floras of Radstock and Bristol. These differences, however, do not appear to indicate any considerable disagreement as regards the horizon, for the percentage of Stephanian plants present is approximately the same in each case. They are best explained as local variations in the distribution of the flora of the period.

The horizon of the so-called Millstone Grits, below the Upper Coal Measures and above the Carboniferous Limestone, is discussed. Reasons are advanced in support of the view that the Upper Coal Measures of the Forest overlie unconformably the so-called Millstone Grits, which in reality are the higher beds of the Carboniferous Limestone Series, which here have an arenaceous facies. True Millstone Grits, as well as Lower, Middle, and Transition Coal Measures, are absent in the Forest of Dean.

The relationships of this coalfield to the neighbouring coalfields of the West of England and South Wales are discussed from the palæobotanical standpoint. It is found that the Forest of Dean basin exhibits no obvious relationship, either to the South Wales or to the Radstock–Bristol coalfields.

The Pennant Grits of South Wales belong to a lower horizon than the markedly arenaceous series (the 'Forest of Dean Stone') of the third division of the Forest. The Radstock–Bristol and Forest of Dean basins are believed to be related tectonically, though not to the main axes of South Wales and the Mendips, but to a secondary cognate uplift, stretching north and south, and approximating to the valley of the Severn. On the other hand, the Forest of Dean does not appear to be related to the Welsh borderland series of coalfields, stretching from Newent to Shrewsbury.

In the case of the Forest of Dean it seems evident that the Lower Carboniferous rocks and the Old Red Sandstones of the area remained elevated above sea-level, and were denuded until the beginning of Upper Coal Measure times, whereas in South Wales depression and deposition set in in Middle Coal Measure times, and in the Radstock-Bristol area during the Transition Coal Measure period. Thus, on the palæobotanical evidence, the relationships of the coalfields of the West of England and South Wales have proved to be more complex than has hitherto been supposed, and this appears to be due, in part at least, to the coincidence of three distinct axes of elevation in the neighbourhood of the Forest of Dean.

REVIEWS.

I.—Géologie du Bassin de Paris. Par M. Paul Lemoine. 8vo; pp. ii, 408, with 9 plates and 136 text-illustrations. Paris, Hermann & Fils; London, Dulau & Co., 1911. Price 15 fr.

(*Second notice, continued from p. 136.*)

THE Portlandian strata comprise, in the upper part, estuarine deposits and fluvio-lacustrine beds with fossils that would connect them with our Purbeck Beds. These latter, however, are not separately recognized, being regarded as the upper part of the Portlandian.

The Lower Cretaceous formations commence with the Aquilonian and Wealdian, which represent the continental facies of the Neocomian. The Aquilonian consists of clays, sands, and iron-ore, in general not fossiliferous. In the Boulonnais there appears in places to be a passage from Portlandian to Aquilonian, but as a rule there is great discordance.

In the Paris Basin the following divisions in descending order are made:—

CRETACEOUS.

Montian Danian		grouped together as 'Calcaire pisolitique'.	
Senonian:	Zones	*Belemnitella mucronata* *B. quadrata*	Aturian.
		Micraster cor-anguinum *M. decipiens*[1]	Emscherian.
Turonian:	Zones	*Holaster planus.* *Inoceramus labiatus.* *Belemnites (Actinocamax) planus.*	
Cenomanian:	Zones	*Schloenbachia varians* and *Acanthoceras rotomagense.* *Scaphites æqualis.*	
Albian:	Zones	*Schloenbachia inflata.* *Hoplites interruptus.* *Douvilleiceras mamillare.*	
Aptian:	Zones	*Exogyra sinuata.* *Terebratella Astieriana.*	
Barremian:		Argiles bigarrées.	
Neocomian:		Calcaire à Spatangues (facies marin). Aquilonian and Wealdian (facies continental).	

This grouping (apart from zones) is the same as that given in the British Museum *Guide to the Fossil Mammals and Birds* (1909).

The Neocomian consists of marine beds (*calcaire à Spatangues*) and lacustrine strata, which include those of Bernissart in Belgium, with *Iguanodon*.

The Barremian also includes both marine and lacustrine strata, mottled clays and sands, and oolitic iron-ore, with *Ostrea Leymeriei* in the lower part, and *Unio*, *Paludina*, etc., above.

The Aptian, characterized by green (glauconitic) sands, overlaps preceding deposits and rests on different Jurassic formations, as in the Ardennes.

The Albian comprises, at the base, green (glauconitic) sands with

[1] *M. cor-testudinarium* auct.

phosphatic nodules of considerable economic importance; the higher strata consist of clays and alternations of sands, marls, and clays (*argiles du Gault*). The Albian reposes on different formations from older Cretaceous to various Jurassic divisions.

In the Cenomanian further overlap took place, and it rests in places directly on the Palæozoic.

Remarks are made on the difficulty in fixing divisions in the Chalk of the Paris Basin, not merely on account of lithological changes, but owing apparently to the presence of similar species of fossils at different levels.

The Cenomanian consists in places of glauconitic sands with *Pecten asper* (found also in Albian), and with phosphatic nodules worked in Marne. Higher beds consist of grey marls and marly limestones with *Holaster subglobosus* and *Acanthoceras rotomagense*. The passage-beds between Cenomanian and Turonian are formed by the white and nodular marl with *Belemnites plenus*. *Rhynchonella Cuvieri* occurs in the higher part of the Lower Turonian, and *Inoceramus labiatus* is found (rarely) in the Upper Turonian with the so-called *Terebratulina gracilis*; higher up in the series *Holaster planus* and *Micraster breviporus* are met with. *Marsupites ornatus* is recorded from the highest part of the Emscherian, and *Bourguetiérinus ellipticus* from the base of the Aturian, which contains both *Belemnitella mucronata* and *B. quadrata*. A full account, with analyses, is given of the phosphatic chalk worked in the zone of *B. quadrata* in Picardy.

It is remarked that chalky conditions continued to exist in northern regions, and notably in Belgium, after they had ceased in France, where no representatives of the Chalk of Spiennes and Ciply are met with. The Chalk of Meudon and Epernay, with *Micraster Brongniarti* and *Ostrea vesicularis*, is grouped with the Aturian or uppermost part of the Senonian. With regard to the Montian division it is stated, on the authority of Munier-Chalmas, that the lower portion is characterized by Senonian and Danian forms of life; the upper portion contains the typical Montian fauna. This fauna, of an age between Cretaceous and Tertiary, includes *Nautilus danicus*, large forms of *Cerithium*, *Cidaris Tombecki*, *C. distincta*, etc. The deposits have been termed 'Calcaire pisolitique',[1] but the grains were due to calcareous algæ. Towards the upper part of the Chalk of Meudon there are indications of the roots of plants beneath the pisolitic bed. Evidence of overlap of this higher bed are noted; it rests on the Emscherian Chalk in the valley of the Mauldre, Montainville.

Some remarks are made on the Clay-with-flints (*Argile à Silex*), which is of different ages, in part post-Pliocene.

The nomenclature adopted for the ages of the Tertiary formations is as follows:—

PLIOCENE.

Sicilian	Sables de St. Prest.
Plaisancian	Couches du Bosc d'Aubigny.
Pontian	Couches à *Cardita striatissima*.
Sarmatian	Conglomérat de Gourbesville.

[1] In the table, p. 132, both Danian and Montian are grouped as 'Calcaire pisolitique', and placed above the Senonian.

MIOCENE.	
TORTONIAN	Faluns de l'Anjou. Faluns de Touraine.
HELVETIAN	Sables de Sologne.
BURDIGALIAN	Sables de l'Orleanais.
AQUITANIAN	Calcaires de l'Orleanais.
OLIGOCENE.	
CHATTIAN	Meulières de Montmorency.
STAMPIAN	Sables de Fontainebleau.
SANNOISIAN	Calcaire de Brie.
EOCENE.	
LUDIAN	Etage du gypse.
BARTONIAN	Sables de Marine: Calcaire de St. Ouen.
ERMENONVILLIAN	Sables de Beauchamp.
LUTETIAN	Calcaire grossier.
YPRESIAN	Sables de Cuise.
SPARNACIAN	Argile plastique.
THANETIAN	Sables de Bracheux.

In this table there is agreement in the subdivision of the Miocene with the series adopted in the British Museum Guide (beforementioned): elsewhere harmony does not prevail. M. Lemoine gives a tabular statement to show the classifications adopted by different geologists, but it does not give all groupings such as those of Renevier (1897). It is desirable that some system of nomenclature be generally adopted, although none can be perfect. The stratigraphical divisions that would be represented on a geological map vary from place to place, and they have an independent practical as well as scientific importance. Chronological divisions should be based on localities where the fauna and flora are well represented.

The Quaternary deposits are grouped as follows:—

RECENT (Actuel)	Period of Metals. Neolithic.
PLEISTOCENE	Upper: Epoch of Reindeer. Magdalenian.
	Middle: Epoch of Mammoth with *Rhinoceros tichorhinus*, etc. Moustierian.
	Lower: Epoch of Hippopotamus with *Elephas antiquus*, etc. Chellean (first indisputable remains of Man in Europe).

The latest stage of the Pliocene is noted as the epoch of *Elephas meridionalis*, with *Rhinoceros etruscus* and *Equus stenonis*; and it is bracketed, with a query, under Palæolithic.

The concluding chapters of this work deal with geomorphology and give a general summary of results. There is a copious bibliography, but it contains no reference to any of Prestwich's works. There are good indexes of species and localities, and a full table of contents.

II.—WIMBLEDON COMMON: ITS GEOLOGY, ANTIQUITIES, AND NATURAL HISTORY. By WALTER JOHNSON, F.G.S. 8vo; pp. 306, 9 plates, 3 maps, text-illustrations. London: Fisher Unwin. February, 1912. Price 5*s.* net.

TO all London dwellers who are lovers of natural history, of prehistoric archæology, and of that later history which lends so much romance to "the grandest of our suburban open spaces", this

book should prove a delightful companion. But readers of this Magazine in particular will be glad to learn that fully one-third of the book is devoted to the geology and physical geography of the Common. This is probably the best part of the book, and, together with the chapter on the Common in prehistoric times, bears witness to the most intimate personal knowledge and study. There are various geological problems connected with Wimbledon Common, but the most important of these and the most difficult to solve is the age of the large sheet of gravel to which it owes its existence. After discussing the various theories with full reference to other parts of the Thames Valley, and after describing in detail the various sections to be seen on or near the Common itself, Mr. Johnson concludes that "the precise age of the gravels must frankly be left undecided. That they are river-gravels belonging to a date anterior to the formation of the Second or 100-foot Terrace may be considered certain", and Mr. Johnson is inclined to think that they are of slightly earlier origin than those of Dartford Heath, and that they were deposited contemporaneously with the Boulder Clay or possibly earlier. Shortly afterwards the plateau was raised, never again to be covered by water. This view agrees in the main with that of Messrs. Hinton and Kennard, and, so far as evidence from Wimbledon Common itself goes, I am aware of nothing to contradict it. It may, however, be worth adding to Mr. Johnson's account of the constituents of the gravel that rather large flints, some white-skinned, some cavernous, appear to be less rare than is usual on the Common itself in a high-lying gravel-pit on the Peek Estate close to Peek Crescent, now closed to the public. The most interesting stone that I have yet found on Wimbledon Common came from a pit near that named E by Mr. Johnson. It is a piece of white quartzite, measuring about $3 \times 2 \times 1$ inches. It appears originally to have had a somewhat rectangular outline, but one surface is gently rounded and water-worn, while the other surface has been ground smooth and nearly flat except for broad, shallow, almost imperceptible furrows running across it, and is remarkably suggestive of glacial action. The exterior of the pebble has the usual reddish-brown stain of the gravel, and where a piece has been broken off, probably by frost, along pre-existing cracks, the interior is seen to be much paler. The interesting feature of the rock is that it is full of the external moulds and imprints of small cylindrical crinoid columnals, with cylindrical lumen and well-marked radiating ridges on the joint-faces. Within two days of my finding this, chance placed in my hands a piece of closely similar rock labelled "Halkin Burr". And I imagine that both specimens represent a Carboniferous sandstone such as is found in Flintshire. Among the constituents of the Wimbledon gravel, Mr. Johnson mentions "many discoidal cakes of pale-grey sandstone". These seem to belong to a different rock from the "red ferruginous grit", which he also mentions, but he does not discuss their origin. Are they not fragments of Sarsen stone?

In almost every exposure on Wimbledon Common and in the neighbourhood, the gravels are underlaid by sands resting on the

London Clay, and these sands have frequently been regarded as remnants of the Bagshot Beds. Certainly there often does appear to be a passage of these sands into the clay. On the other hand, it does not appear possible in any section to draw a clear line between these sands and the overlying gravel, so that one feels with Mr. Johnson it is safer to go no farther than to say "rearranged Bagshots".

Many an interesting question raised by the charming Beverley or beaver-brook is discussed, and this leads us on to the ancient Bensbury, absurdly called Cæsar's Camp, strongly entrenched on the dun from which the followers of Wimbald overlooked the Coombe.

It does not fall within our province to follow Mr. Johnson through the early mediaeval and modern history of the locality, though the geologist will not rightly comprehend some physical features if he forgets how many a superficial change has been due to Rifle Associations, Golf Clubs, and Conservators.

In other departments of natural history Wimbledon Common is so rich that a few omissions are not to be wondered at. It might, however, have been mentioned that the hawfinch is a regular resident and that the hedgehog is not uncommon. Mr. Johnson does well to enumerate the exotic trees of the neighbouring gardens, but he should not have forgotten the old cork-tree in Marryat Road. We read of Captain Marryat and his father, but not of Mrs. Marryat, F.R.H.S., to whom so much of our imported beauty is due. And how would Swinburne, who so loved this beauty, like to have been called "Sir Algernon"?

Truly Wimbledon Common should be in the mind of the public and especially of naturalists. Above all, just now, when its health and beauty are being threatened by the sale of lands in Kingston Vale, lands on which farming operations at present serve to intensify the rural charm of the scene, but which we dread to see covered with rows of mean streets, disfiguring the wonderful view and blackening the Common with their smoke. Our public-spirited fathers who lived round this Common had a hard fight to keep it, and its beauties have since been preserved for the public by a heavy annual expenditure on the part of the neighbouring residents. They it is who have dipped further into their own pockets to save the land to which we have just referred. Never before have they appealed to the public, but now time is running short and there is £19,000 yet to be raised before the end of July. They have done what they can, and now they are asking Londoners and others who share the Common with them to come to their help. Further information may be obtained from Mr. Richardson Evans, Secretary to the Extension Committee, The Keir, Wimbledon, and geologists should not be the last to send their subscriptions of whatever size to the Treasurer, Sir Robert Hensley, Glenton House, Putney.

F. A. Bather.

III.—Radio-activity and Geology.

THE bearings of radio-activity on geology are discussed by Professor T. C. Chamberlin (*Journ. Geol.*, xix, November–December, 1911). He refers first to the old view that "the primitive gaseous or quasi-gaseous earth-mass was held to have passed later into a molten globe, and the subsequent incrusting of this to have entrapped in the interior the heat supply of subsequent ages". To the condensation of the nebula, whether gaseous or a quasi-gaseous meteoric swarm, was attributed the intense heat. An alternative view, developed by the author before the discovery of radio-activity, was the planetesimal hypothesis, which was "built on the belief that earth grew up gradually by the slow accession of discrete orbital matter", and that "the internal heat arose mainly from the self-compression of the earth-mass as it grew". The chief purpose of the present paper is to set forth the "harmony between the new light shed by radio-activity and the tenets of the planetesimal view". The original source of radio-active substances, so far as known, is in the igneous rocks; except in meteorites which appear to contain but meagre amounts of the substances, accessions of radio-active material from without the earth has not been demonstrated. It is pointed out that "from the igneous rocks the radio-active substances are dissolved and disseminated through the waters and carried wherever they go, while from both the rocks and the waters the emanations are given forth into the atmosphere". Therefore it is that radio-active matter is found "in practically all the rocks of the surface of the earth, in practically all the waters, and in practically all the atmosphere".

The author deals with the inference that liquefaction and eruption of the igneous rocks are dependent on the heat derived from radio-activity. Weathered igneous rocks are found to carry less radio-active matter than fresh rocks; nevertheless, soils "still retain notable radio-activity, but a part of this is probably a redeposit from the atmosphere".

The distribution of volcanoes past and present is referred to. The primitive shields, scarred with intrusions, are almost immune now; but they have suffered denudation, and "according to the hypothesis of concentration at the surface, this lost matter carried a relatively high proportion of radio-active substance".

The author supports the view, held by some geologists, that while "the rise of the denuded embossments of the crust was attended by elastic expansion of the whole sector of the earth beneath . . . that the protruding portions of the continents tend to lateral creep, and that this carries with it tensional effects as well as some further elastic expansion. At the same time the penetration of surface-water is promoted, and this aids effectively in carrying off the heat of the outer crust".

It is interesting, therefore, to remember that "the movement of igneous matter and of waters and gases heated by it has been made to play an essential part in the working concepts that have been based on the planetesimal hypothesis".

IV.—The Lower Palæozoic Corals of Chillagoe and Clermont. Part I. By R. Etheridge, jun. Queensland Geological Survey, Publication 231. pp. 8; plates A–D. Brisbane, 1911.

Of the five new corals that are described by Mr. Etheridge from the Lower Palæozoic of Chillagoe and Clermont, three are referred to the genus *Cyathophyllum* and two to *Spongophyllum*. *C. Dunstani*, n.sp., from Clermont, is related to two Devonian species of Europe and America—*C. quadrigeminum*, Goldfuss, and *C. hexagonum*, Goldfuss.

C. (?) *clermontensis*, n.sp., also from Clermont, is related to the Devonian species *C.* (?) *helianthoides*, Goldfuss, and *C.* (?) *damnoniense*, Goldfuss.

C. chillagoensis, n.sp., from Chillagoe, shows points of resemblance to and difference from *C. hypocrateriforme*, Goldfuss.

Spongophyllum cyathophylloides, n.sp., from Clermont, is compared with *S. bipartitum*, Etheridge, jun., from the Upper Silurian rocks of Yass, New South Wales; and *Spongophyllum* sp., a new form from Chillagoe, is distinguished from *S. cyathophylloides* by a limited number of septa and copious endothecal tissue.

The presence of the genus *Halysites* shows the Chillagoe Limestones to be of Silurian age, but that of the Clermont Limestone has yet to be determined.

V.—The Geology of Knapdale, Jura, and North Kintyre. By B. N. Peach, the late J. S. G. Wilson, J. B. Hill, E. B. Bailey, and G. W. Grabham: with notes by C. T. Clough, S. B. Wilkinson, W. B. Wright, and H. B. Maufe; and petrological descriptions by J. S. Flett. 8vo; pp. viii, 149, with 8 text-illustrations and 7 plates. 1911. Price 4*s.* 6*d.*

This memoir is an explanation of the Scottish Geological Survey Sheet 28, with parts of 27 and 29. Sheet 28, now issued (at the price of 2*s.* 6*d.*), is admirably colour-printed, and although it does not contain the whole of Jura, that island is fully described in the memoir without regard to the limits of the map.

Apart from the Glacial Drifts, the Raised Beaches, Alluvium and Peat, the area consists of Metamorphic Rocks (Dalradian), intersected by igneous dykes and some sills, the ages of which are doubtfully given as Old Red Sandstone, Permo-Carboniferous, and Tertiary.

Jura with its 'Paps', which rise to an elevation of more than 2,400 feet, is composed mainly of white quartzite. It is not a very hospitable-looking area, judging by the coast-views with raised beaches, but appears more attractive in the view of Dolerite dykes (plate vi).

The mainland is more varied in its geology, and consists of limestone, quartzite, clay-slate, and altered igneous rocks or 'epidiorites', which are folded together so that the outcrops of each run in long narrow strips directed mainly to the north-east. The numerous inlets by which the sea penetrates far inland (Loch Sween, Loch Tarbert, etc.) have the same trend as the rock outcrops, and are old land valleys which have been drowned by submergence. Around

the coast is a remarkable series of raised beaches showing changes of the level of land and water, and indicating that the sea must at one time have stood at least 100 feet higher than at present. Photographs are reproduced in the volume to show the white gravels that cover these raised beaches on the west of Jura. There is also a fine view of pillow lavas associated with the black slate and limestones of the Loch Awe Group at An Aird. The concluding chapter contains an account of the mineral ores, glass sand, silica bricks, building-stones, slates, and other economic products of the district.

VI.—Brief Notices.

1. Coals of the State of Washington. By F. Eggelston Smith. Bull. ccccIxxiv of U.S. Geol. Surv., 1911. pp. 1–206, with 8 plates.

THIS memoir contains a full account of each coal-working in the State of Washington, with geological sections and chemical analyses of the seams. There is also included an interesting detailed report of the methods of sampling, the chemical and physical properties of the coals, their impurities, and their uses.

2. The Recent and Fossil Mollusks of the genus *Alvania* from the West Coast of America. By Paul Bartsch. No. 1863. From the Proceedings of the United States National Museum, vol. xli, pp. 333–62, with plates 29–32. Washington, 1911.

A VERY complete account of Gastropod shells of the genus *Alvania* is given in this paper. Eighteen new species are described, and two of these are found as fossils, and as fossils only, viz. *A. pedroana* and *A. fossilis*, both from the Sand Rock at San Pedro, California. A history of research and a key to the genus precede the description of species. Most of the types of the new species were dredged by the United States Bureau of Fisheries steamer *Albatross*.

3. New Labyrinthodont from Kansas.—Labyrinthodonts are rare in the Coal-measures of North America, so the description of *Erpetosuchus kansensis*, Moodie, is especially welcome. The specimen consists of a fragment of a skull, two ribs, and the larger part of the left ramus of a mandible. These are preserved in the U.S. National Museum, and Mr. R. L. Moodie describes them in the Proceedings, vol. xxxix, pp. 489–95, 1911.

4. Water Divining and Radio-activity.—Mr. Beeby Thompson has given an account of some experiments which showed conclusively that three reputed 'water diviners', without any real knowledge of what they were about, were affected by the presence of radium emanation (Journ. Northamptonshire Nat. Hist. Soc., xvi, September, 1911). Mr. Thompson is not convinced that the diviners can be relied upon to find water, as in thirty-six records of their attempts in Northamptonshire, twenty were complete failures, and eight were virtual failures by reason of the fact that water was present everywhere below ground and one particular spot was no better than another. It is suggested that experiments be made on waters and rocks that are known to possess radio-active properties.

5. Dingle Beds.—In a report on the 'Dingle Bed' rocks in the Dingle Peninsula, co. Kerry (Proc. Roy. Irish Acad., xxix, section B, No. 7, 1912) Mr. Alexander McHenry comes to the conclusion that the true position of the strata is below the Wenlock rocks, and that they are probably of Llandovery age.

6. Gypsum Deposits of Canada.—A report on the Gypsum deposits of the Maritime Provinces, Nova Scotia, New Brunswick, and the Magdalen Islands, has been prepared by Mr. W. F. Jennison (Department of Mines, Canada, 1911). The report shows by descriptions, maps, and photographs the vast extent of the deposits, the uses of gypsum, and the processes and cost of manufacturing it into a marketable product. The Canadian gypsum deposits are all regarded as forming part of the Lower Carboniferous. The origin of gypsum is discussed, and the distribution of the mineral in various parts of the world is given.

7. Climatic Changes in Japan since the Pliocene Epoch.—This subject is discussed by Professor Matajiro Yokoyama (Journ. Coll. Sci. Tokyo, xxxii, art. 5, 1911). He concludes that the temperature in Central Japan has gradually increased since the earlier Pliocene, attaining its maximum in the Diluvial (Pleistocene), and then again decreasing to the present time. No evidence of glacial action has been met with in Japan.

REPORTS AND PROCEEDINGS.

Geological Society of London.

1. *January* 24, 1912.—Professor W. W. Watts, Sc.D., LL.D., M.Sc., F.R.S., President, in the Chair.

The following communication was read:—

"The Upper Keuper (or Arden) Sandstone Group and Associated Rocks of Warwickshire." By Charles Alfred Matley, D.Sc., F.G.S.

Under the name of the Arden Sandstone Group the author describes the stratigraphy of a sandstone zone in the Keuper Marls of Warwickshire, which is exceptionally well exposed in the area formerly occupied by the Forest of Arden.

This zone varies in lithological composition and thickness. It is never wholly a sandstone, but always contains beds of light-grey and pale-green shale, marl, and mudstone, which in places make up almost the whole of the zone. The sandstone, where present, usually forms thin, flaggy, white or light-grey beds, and exhibits ripple-marks, current-bedding, and surfaces with footprints and sun-cracks. The zone contains *Estheria minuta*; plants; teeth, spines, and scales of fishes; tracks and remains of labyrinthodonts and reptiles; and occasional casts of molluscan shells. The band is typically 20 to 25 feet thick, increasing sometimes to 40 feet or more; but it thins, especially eastwards and south-eastwards, to 4 or 5 feet.

The zone was first described by Murchison & Strickland in 1837, but has not hitherto been completely mapped. The author traces

it from the type-locality at Shrewley over an area of 108 square miles, and finds that it forms a continuous deposit at an horizon between 120 and 160 feet below the base of the Rhætic. He accepts the view of Murchison & Strickland, that it is the same formation as the Upper Keuper Sandstone of Worcestershire and Gloucestershire, and he also correlates with it the similar deposit at Leicester described by Plant. The formation thus appears to have been laid down over an area at least 70 miles in length, and was probably formed, as an episode in the history of the Keuper Marls, by an irruption of the sea into the Keuper Marl area. It represents a phase corresponding to that of the Rhætic Bone-Bed and the Tea-green Marls, but of somewhat earlier date.

The associated Keuper Marls have been examined, merely in order to establish their stratigraphical relations with the Arden Sandstone. So far as his observations go, the author is inclined to the view of the older observers that the Marls are aqueous deposits, though possibly containing much wind-borne material, deposited in a shallow lake undergoing strong evaporation and subjected to occasional irruptions of the sea. They represent the closing phase of Triassic 'continental' conditions in the English Midlands, when the slow subsidence which was soon to bring in marine Rhætic and Liassic deposits was in progress, and produced that overlapping of the Keuper rocks on to the higher grounds of the Triassic land-surface which is observable in the neighbouring districts of the Lickey Hills, Nuneaton, and Charnwood Forest.

The tectonics of the area are explained by sections and by a contour map of the upper surface of the Arden Sandstone, which show that, while the beds as a whole are tilted south-eastwards, there are numerous shallow cross-folds with Charnian (north-west to south-east) axes and others with Pennine (north to south) axes. The majority of the faults have a Charnian trend.

The paper also records three well-borings through the Marls into the Lower Keuper Sandstone.

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2. *February* 7, 1912.—Professor W. W. Watts, Sc.D., LL.D., M.Sc., F.R.S., President, in the Chair.

The following communication was read:—

"On an Inlier of Longmyndian and Cambrian at Pedwardine (Herefordshire)." By Arthur Hubert Cox, M.Sc., Ph.D., F.G.S.

The inlier in question comprises a strip of country about a mile in length and half a mile in breadth, situated near the border of Herefordshire and Radnorshire, about 15 miles south of Church Stretton. It lies on the well-known north-east and south-west line of dislocation which extends through that town.

Wenlock and Ludlow Beds occupy most of the area around Pedwardine, but the occurrence of Cambrian Shale yielding *Dictyonema* has long been known. The *Dictyonema* Shales dip steeply westwards towards a series of red and green conglomerates and grits, with which an occasional thin shale-band is interbedded.

The latter beds, previously mapped as Llandovery, are here referred to the Longmyndian. They also dip steeply westwards, and have suffered considerable disturbance, accompanied by overthrusting from the west. They are quite unfossiliferous, and neither on lithological nor on structural grounds can they be regarded as Llandovery strata resting unconformably upon the Cambrian. Their nearest equivalents are found among the Longmyndian grits at Hopesay, and in the Bayston Group of the main Longmynd area. These Longmyndian grits at Pedwardine have apparently been carried south-eastwards over the Cambrian along an almost horizontal thrust-plane.

There is also present a small remnant of Bala grits which dip gently eastwards, and rest with strong unconformity upon the Cambrian shales. The undisturbed character of these Bala Beds suggests that the neighbouring thrust may be of pre-Bala date.

Later faulting along a north and south line has brought the members of these older formations against Wenlock and Ludlow Beds. From the greatly disturbed character of all the Silurian strata to the west of the inlier, as contrasted with the undisturbed condition of the beds on its eastern side, it would appear that this inlier is part of a barrier which has preserved the district lying to the east from the effect of the post-Silurian movements.

Annual General Meeting.

3. *February* 16, 1912.—Professor W. W. Watts, Sc.D., LL.D., M.Sc., F.R.S., President, in the Chair.

The Reports of the Council and of the Library Committee were read. It was stated that 47 new Fellows had been elected during the year, and that the losses by death, resignation, and removal amounted to 52 (1 more than in 1910), the actual decrease in the number of Fellows being, therefore, 5 (as compared with an increase of 5 in 1910). The total number of Fellows on December 31, 1911, was 1,294.

The Balance-sheet for that year showed receipts to the amount of £3,029 19*s.* 11*d.* (excluding the balance of £452 19*s.* 2*d.* brought forward from 1910) and an expenditure of £3,007 7*s.* 3*d.*

Reference was made to the transference of the collections in the Society's Museum to the authorities of the Natural History Museum and of the Museum of Practical Geology, and to the consequent extension of the Library.

The Reports having been received, the President presented the Wollaston Medal to Dr. Lazarus Fletcher, F.R.S., addressing him as follows:—

Dr. Fletcher,—In the long list of distinguished men who have received from the Geological Society the Wollaston Medal, whether struck in palladium or in gold, there are not only many geologists of great eminence for their studies in other branches of the science, but a preponderance of those whom the donor doubtless had more particularly in mind in founding his Medal 'to promote researches concerning the mineral structure of the earth'. The list does not contain the names of many pure mineralogists, but in asking you to

accept the Medal this year the Council has desired to place you in company with Bischof, Naumann, Dana, von Hauer, Des Cloiseaux, Story Maskelyne, and von Groth. Succeeding in the Keepership of the Mineralogical Department of the British Museum to the real founder of that Department, and the one who made it an expression of the best side of mineralogical science, you impressed your own personality upon it, and left it more valuable, more useful, more representative, more simple. The last was no light task, and it required, in a mathematician of such high culture and ability, an extraordinary and very unusual type of intellect to write an introduction to the study of minerals, and to arrange a collection to illustrate it, without the use of a single mathematical expression; and yet to produce a book which is at once intelligible to the museum visitor, a scientific guide to the student, and a joy to the professed mineralogist. If this were all it would be a great achievement, but you have done as much for the study of rocks and even of meteorites. And all the time you have been engaged in research of a most painstaking and minutely accurate character on the constitution of meteorites and of certain obscure and rare minerals, leaving, with characteristic unselfishness, the more attractive problems to your colleagues. If we add to this your theoretic work on the effect of heat on crystals, your elegant treatment of crystallographic optics, culminating in the conception of the optical indicatrix, your fastidious and dainty choice of expression in order to eliminate the slightest trace of ambiguity from your descriptive work, and, finally, your steadfast devotion to the well-being of the Mineralogical Society, with which you have been so closely identified, we have a record of devotion to your science and duty which has, to the delight of your friends, been worthily crowned by your appointment to the Directorship of our great National Museum of Natural History.

I ask you to accept the Wollaston Medal, not for the sake of yourself and your work alone, but as a token of acknowledgment by the Science of Geology of part of her debt to the science which you so worthily represent in our country.

Dr. Fletcher replied in the following words:—

Mr. President,—I thank the Council very heartily for the distinction that has been conferred upon me by the award of this medal, given more especially, I am told, for my researches in connexion with the crystalline forms and crystal optics.

Each recipient of the Wollaston Medal must have heard with a thrill of pleasure the news that such a compliment had been paid to him by his fellow-workers; but doubtless the pleasure has been especially great to the crystallographers, for they cannot but have felt that crystallographic researches deemed worthy of such recognition must have brought some additional honour, however slight, to the memory of the many-sided Wollaston, who, by his invention of the reflective goniometer, had first made possible the measurement of crystalline forms with astronomical precision.

As regards crystal optics, the subject is too abstruse to appeal to the popular imagination. But, for the mathematician at least, there is wonderful beauty in the thought that, for every biaxal crystal, notwithstanding all our uncertainties relative to the luminiferous ether, to each point on an ellipsoid there corresponds a single ray of light, with three physical characters—namely, the direction and velocity of transmission and the plane of polarization—all definitely and simply related to the geometrical characters of the ellipsoid at that point. I may mention that it was some time after the perception of this relationship before I could convince myself of its truth; for it seemed that, after the harvest that had been gathered from the wave-surface by Fresnel, Sir William Hamilton, MacCullagh, Sylvester, and others, nothing was left for the gleaner, and that the relationship, if true, would have been discovered long ago.

It may be not without interest if I add that the direction of my work in life has been much influenced by two Wollaston Medallists, Professor P. von Groth and the late Professor Maskelyne. In the year 1876, when I was Demonstrator in Physics for Professor Clifton at Oxford, I saw a new book lying on his study table: it was Groth's *Physikalische Kristallographie*, then just published.

I was so much interested in scanning its pages that I ordered a copy, and read it slowly and carefully at my leisure. Professor Clifton mentioned my interest in crystals to his Oxford colleague, that enthusiastic crystallographer, Professor Maskelyne, and I was invited to call at the British Museum; the visit had for result a brief official connexion with him in the Mineral Department, and, what was still more important, a long-continued friendship that ended only with his life thirty-four years later. To both of them I am thus under a heavy debt of gratitude.

The President then presented the Murchison Medal to Professor Louis Dollo, F.M.G.S., addressing him as follows:—

Professor DOLLO,—The Council have awarded you the Murchison Medal in recognition of the importance of your numerous contributions to our knowledge of Vertebrate Palæontology. Twenty-three years ago they encouraged your early work by the award of the Lyell Fund, and since that time the Society has continued to follow your researches with interest, enrolling you first as a Foreign Correspondent and then as a Foreign Member. The promise of your earliest publications on the Wealden Reptiles of Bernissart has been fulfilled in your later papers on the Cretaceous Mosasaurians and various other vertebrate fossils; and your philosophical insight has illumined many difficult problems which other authors found obscure. I need only refer to your interesting essays on the evolution of the Dipnoan Fishes, on the auditory apparatus of Mosasaurians and Ichthyosaurians, and on the feet of Marsupials, which are classics in modern palæontological literature. Your demonstration of the principle of 'irreversibility' in organic evolution has led to important conclusions which are now generally appreciated; and your treatise on ethological palæontology has opened the eyes of observers to the evidences of correlation between structure and function which may be observed in several classes of fossil animals. Your papers never fail to embody suggestions which are stimulating and conducive to new points of view.

Professor Dollo, in reply, said—

Monsieur le Président,—Permettez-moi d'exprimer mes sentiments de profonde reconnaissance à la Société géologique de Londres pour le grand honneur qu'elle veut bien me faire en me décernant la Médaille de Murchison.

Il y a près d'un quart de siècle déjà, votre Société eut la bonté d'encourager mes premiers travaux, en m'attribuant le Fonds Lyell: c'était le temps des Iguanodons et des Mosasaures.

Depuis, sans jamais cesser de m'occuper des Reptiles fossiles, j'ai été amené à aborder de multiples problèmes de Paléontologie éthologique, et, même, tout récemment, il me fut donné, à cette occasion, de faire une incursion dans le Monde silurien. La grande ombre de Murchison a accueilli ma hardiesse avec indulgence, puisque je puis, aujourd'hui, vous assurer de ma gratitude, en recevant la Médaille fondée par cet illustre Géologue.

Mais je n'en ai pas fini avec les Reptiles fossiles de la Belgique, dont, prochainement, je suis heureux de pouvoir vous l'annoncer, le Musée de Bruxelles exposera une importante série nouvelle, provenant des Terrains éocène, oligocène et miocène, notamment un squellete gigantesque, presque complet, de l'*Eosphargis gigas*, découvert d'abord en Angleterre.

Et, maintenant, commencent à arriver les Reptiles fossiles du Congo, encore très fragmentaires, mais pourtant caractéristiques, dont j'ai pu signaler les premiers restes à l'Académie royale de Belgique, au début de cette année.

Après trente ans de carrière, une tâche considérable se dresse donc encore devant moi: en cette occurrence, la Médaille de Murchison sera un stimulant précieux, qui me soutiendra dans mes efforts, et c'est pourquoi je vous en remercie.

In presenting the Lyell Medal to Philip Lake, M.A., the President addressed him as follows:—

Mr. LAKE,—As an old friend of many years' standing, I regard it as a great privilege to hand you the Lyell Medal which the Council has awarded to you, as

to one who 'has deserved well of the Science'. But your work has been so many-sided, that it is not easy to choose that on which to lay the chief emphasis. You have dealt with the stratigraphy and tectonics of the older Palæozoic rocks in those more difficult regions which have been left by other observers till last, as in the Dee Valley and about Cader Idris. You have treated of the petrology and the structural relations of both interbedded and intrusive igneous rocks, and in doing so have carried down our knowledge of igneous activity well into the Cambrian Period. You have utilized your knowledge of the structure and relations of the rocks, and the superficial deposits resting upon them, to form a theory as to the history of the Dee and of Bala Lake, and have applied this theory to the general drainage system of North Wales. And last, but far from least, you have done much to elucidate the structure and classification of certain forms of Trilobites, more especially *Acidaspis*, and are now engaged upon an elaborate monograph, part of which is already published, on the Cambrian Trilobites, a work the need for which has long been felt by workers among the older rocks in this country. Your services to Geology do not end here, for by your teaching and organization you have contributed much to the study of geology and geography in Cambridge and its vicinity; while by your translation and adaptation of Kayser's *Comparative Geology*, and the publication, in conjunction with Mr. Rastall, of your Textbook, you have placed the students of stratigraphical geology deeply in your debt.

Mr. Lake, in reply, said—

Mr. President,—I am deeply sensible of the honour that the Council has conferred upon me by the award of the Lyell Medal.

It is an especial pleasure to find in the list of former recipients the names of two of those to whom I am most indebted for my geological training—Professor Hughes and Dr. Marr.

But I do not forget that it is to Professor Lebour, one of the Murchison Medallists, that I owe my first introduction to geology. Without his guidance and help I should never have become a geologist, nor should I ever have come under the influence of Cambridge.

Circumstances have seldom permitted me to devote my undivided attention to the study of our science, and my geological work has suffered accordingly. It is encouraging to find that it has not altogether failed, and I still hope in the future more fully to justify the award for which I now thank the Council.

In presenting the Balance of the Proceeds of the Wollaston Donation Fund to Charles Irving Gardiner, M.A., the President addressed him in the following words:—

Mr. GARDINER,—The vacation times of a man so strenuously occupied as yourself are very precious to him, and it is a compliment to the fascination exercised by scientific research, and especially by the pursuit of geological investigation, that you willingly give up so much of your holidays to field-work in your chosen science. Mainly in association with Professor Reynolds, you have patiently and unwearyingly carried out your steadfast programme, which I am glad to think was suggested to you by myself, of increasing our knowledge of the older Palæozoic rocks of Ireland. Beginning at Kildare, you passed thence by way of Landay to Portraine, at each stage throwing new light on the succession, and at the last-named locality unravelling the different types of conglomerates, which in that neighbourhood have been produced by earth-movement. Shifting your operations to the south, you threw new light on the succession of Silurian rocks in that region and on the unusual association of contemporaneous igneous rocks with them. Then you proceeded to Mayo and Galway, dealing with the areas of Tourmakeady, Lough Nafooey, and Glensaul in turn; and, judging by your latest paper, you seem to have been as successful in this exceedingly difficult ground as in the simpler areas previously dealt with. The Council, in awarding you the Balance of the Proceeds of the Wollaston Fund, does so, not only in recognition of good work done, but in confidence that you will carry on similarly good work in the future.

The President then presented the Balance of the Proceeds of the Murchison Geological Fund to Dr. Arthur Morley Davies, addressing him as follows:—

Dr. MORLEY DAVIES,—It is recognized by your friends and colleagues that the original work which you have completed has been accomplished under singular difficulties and in the stress of a very busy life. You have been specially attracted by the series of anomalous deposits, which in various parts of Buckinghamshire and the vicinity come between the Oxford Clay and the Chalk, and several members of the sequence have been elucidated by your careful and detailed stratigraphical and palæontological research. You have collected many of these results, and combined them with other information, in your clear and concise summary of the Geology of Buckinghamshire published in *Geology in the Field*. You have spent much thought and industry on the preparation of a tectonic map of the British Isles, a work long needed by geologists, and one which we hope will shortly see the light. You have sympathies also with the geographic side of science, as testified by your work on the *Geography of the British Isles*, your admirable little volume on the Geography of Buckinghamshire, and a number of papers dealing with such subjects as lie on the borderland between history and geography. You will perhaps also allow me to express here my very warm appreciation of the great value of your work as a colleague at the Imperial College of Science and Technology, and it is this which makes it an exceptional pleasant duty for me to hand you the Balance of the Murchison Fund during my last year of office.

In presenting a moiety of the Balance of the Proceeds of the Lyell Geological Fund to Dr. Arthur Richard Dwerryhouse, the President addressed him as follows:—

Dr. DWERRYHOUSE.—When, as Secretary of the Society, it was my duty to read the manuscript of your paper on the Glaciation of the Valleys of the Tees and other northern rivers, I got the impression that it was a model of scientific exposition, an opinion confirmed when I saw it in print. But this represents only a part of the service that you have rendered to the Glacial Geology of the North and Midlands of England and of the North of Ireland. In each locality you have discovered something new and something throwing fresh light upon the conditions that prevailed during the Glacial Epoch. But you have also been able to pursue inquiries along other lines; for instance, the circulation of underground waters, the origin of caves, and the weathering of rocks, while in your Presidential addresses to the Liverpool Geological Society you have dealt with far larger geological problems. As a contributor to the *Glacialists' Magazine*, as Secretary for several years of Section C of the British Association, and as a member of the Committee on Erratic Blocks, you have discharged other duties to your science. In your papers on the Eskdale Granite and its metamorphism, you have approached a difficult petrographical problem, and made an important contribution to its solution. Finally, your recent work on geological maps will be of great help in educating students to deal in the laboratory with geological problems which they will have later to face in the field. I have the pleasure to hand you a moiety of the Balance of the Proceeds of the Lyell Geological Fund.

The President then presented the other moiety of the Balance of the Proceeds of the Lyell Geological Fund to Robert Heron Rastall, M.A., addressing him as follows:—

Mr. RASTALL,—It is fitting that both authors of so novel and important a work as *Lake and Rastall's Textbook* should receive awards from the Geological Society on the same occasion. In making this award, however, the Council had in mind not only that work, but the labour which you have for many years devoted to your science in original research. You have been attracted most strongly by petrographical problems, as is indicated by your contributions to Dr. Hatch's work on that subject, by your papers on the

igneous rocks of Buttermere and Ennerdale, on the inclusions in the Mount-Sorrel granite, on the Skiddaw granite, on the rocks surrounding the Kimberley diamond pipes, and on the dedolomitization of marble at Port Shepstone. One might perhaps even venture to think that your chief interest in the Cambridgeshire boulders was aroused by the numerous rock-types which are thus to be found scattered over a country not otherwise rich in problems of the more solid geology, were it not for your contribution on the Cambridge district to *Geology in the Field*. You have not neglected other sides of the science, and your paper on the Dogger of Blea Wyke and that on the Ingletonian Series are important contributions to our detailed knowledge of the position and character of these strata. Your latest paper has dealt with your observations in South Africa, and involves, not only an important elucidation of the tectonics of the area, but, if its conclusions are accepted by South African geologists, a new reading of the relations of the strata there. It is my pleasant duty to hand to you the Balance of the Proceeds of the Lyell Fund.

The President thereafter proceeded to read his Anniversary Address, giving Obituary Notices of several Foreign Members, Foreign Correspondents, and Fellows deceased since the last Annual Meeting, including Dr. A. Michel-Lévy (elected a Foreign Member in 1893); M. Édouard Dupont (el. 1897); Dr. C. A. White (el. 1899); Professor G. Stefanescu (elected a Foreign Correspondent in 1899); Dr. A. E. Törnebohm (el. 1910); Sir J. D. Hooker (elected a Fellow in 1846); Professor T. Rupert Jones (el. 1852); Professor N. Story Maskelyne (el. 1854); G. Maw (el. 1864); G. P. Wall (el. 1862); F. Braby (el. 1864); G. Attwood (el. 1872); S. F. Emmons (el. 1874); W. Shone (el. 1874); R. D. Roberts (el. 1875); Rev. E. M. Cole (el. 1889); G. E. Coke (el. 1901); and A. Longbottom (el. 1909).

He then made reference to the chief event of the year in the Society's affairs—the transference of the collections in the Museum to the authorities of the British Museum (Natural History) and of the Museum of Practical Geology; and dwelt at some length on the consequent re-arrangement and extension of the Library.

The main subject of the Address was a consideration of the methods to be adopted for determining the actual extent of this country's natural resources in the matter of coal, and the President remarked that the inquiries of the Coal Commissions have shown that, of the coal left unworked in Britain, 100,000 millions of tons remain in the proved and 40,000 millions in the unproved coal-fields. It is pointed out that it is as safe to reckon confidently on the latter quantity as on the former.

Careful estimates by competent authorities show that this quantity of coal is likely to become exhausted between 2130 and 2200 A.D. according to the precise basis upon which the calculation is made.

It becomes, therefore, a serious matter to ascertain whether or no we possess other supplies of workable coal not included in the estimate of the Commissioners, and it is pointed out that in Eastern and Southern England there exists an area of Palæozoic rocks unconformably covered by Neozoic rocks larger in extent than the uncovered Palæozoic outcrop of England and Wales.

This area has only been explored in regions which are in direct prolongation of the exposed coal-fields, and by a very small number of borings put down elsewhere. Some of these have demonstrated the existence of Coal-measures or other Carboniferous rocks, and none

have yet proved a Neozoic cover so thick as to preclude the possibility of successfully working any coal which may be found beneath it.

It is argued that the time has now come for the organization of a systematic survey of this area by means of a considered series of borings so planned as to investigate the structure of the concealed Palæozoic floor, to ascertain the thickness of cover, to locate any coal-basins which may form part of the floor, and to elucidate their exact tectonic conditions in order to determine their suitability for profitable working.

It is admitted that such an exploration would involve many practical difficulties and would introduce a new practice into British institutions, but it is pointed out that similar methods have been employed in foreign countries and even in British Colonies.

It is urged that the close dependence of the future of the nation on its coal-supplies justifies a new departure, and that it would be a wise act of statecraft to take deliberate measures to devise a comprehensive and well-considered scheme of exploration, the results of which might be at hand for application before the growing scarcity of coal shall have begun to produce its inevitable economic consequences upon the manufactures and upon the very conditions of existence in this country.

The Ballot for the Council and Officers was taken, and the following were declared duly elected for the ensuing year:—

OFFICERS:—*President:* Aubrey Strahan, Sc.D., F.R.S. *Vice-Presidents:* Professor Edmund Johnston Garwood, M.A.; John Edward Marr, Sc.D., F.R.S.; Richard Dixon Oldham, F.R.S.; Professor W. W. Watts, Sc.D., LL.D., F.R.S. *Secretaries:* A. Smith Woodward, LL.D., F.R.S., F.L.S.; Herbert Henry Thomas, M.A., B.Sc. *Foreign Secretary:* Sir Archibald Geikie, K.C.B., D.C.L., LL.D., Sc.D., Pres.R.S. *Treasurer:* Bedford McNeill, Assoc.R.S.M.

The other Members of COUNCIL are:—Henry A. Allen; Tempest Anderson, M.D., D.Sc.; Charles William Andrews, B.A., D.Sc., F.R.S.: Henry Howe Arnold-Bemrose, J.P., Sc.D.; Professor Thomas George Bonney, Sc.D., LL.D., F.R.S.; Professor William S. Boulton, B.Sc., Assoc.R.C.S.; James Vincent Elsden, D.Sc.; John William Evans, D.Sc., LL.B.; Robert Stansfield Herries, M.A.; Herbert Lapworth, D.Sc., M.Inst.C.E.; George Thurland Prior, M.A., D.Sc.; Clement Reid, F.R.S., F.L.S.; Arthur Vaughan, M.A., D.Sc.; and the Rev. Henry Hoyte Winwood, M.A.

CORRESPONDENCE.

DISCOVERY OF HUMAN REMAINS. OBLITERATION OF TRACES OF INTERMENT.

SIR,—A skeleton has just been found buried in the top of the Barrington Beds under circumstances which are at the present time of special interest.

'Barrington Beds' is the name given to a deposit of freshwater origin occurring over an area of very limited extent near the village of Barrington, some seven miles south of Cambridge. The locality has recently been visited by the Geologists' Association, and described in their Proceedings (vol. xxii, pt. v, p. 268, 1911).

I took a party of students there yesterday to examine the sections and in order to facilitate our work I employed labourers to remove

the top. At the bottom of the surface soil, exactly where the head of the man in the white straw hat comes in fig. 1 of the report above referred to, the workmen came upon the bones of a child about twelve years of age. There was nothing, as far as I could ascertain or see, in the appearance of the overlying soil to suggest an interment until the bones were reached. There was, however, a small irregular depression excavated in the top of the underlying chalky loam, and in this the body lay as if it had been buried in a contracted position. The bones were crushed and disturbed by the settling down of the overlying earth during the decay of the soft parts, and were much decomposed, but there was nothing obviously abnormal in them. In such cases we have to remember that the surface soil is always on the move, and that all traces of a grave or other pit quickly disappear in a homogeneous superficial deposit. It is only where there are stratified beds of sand or gravel and the continuity of the layers is interrupted that the infilled grave or pit can be clearly seen in section.

I once saw a remarkable case of the obliteration of the signs of interment at Faversham in North Kent. Here an interesting cemetery of Roman and Saxon age was entirely carried away in the course of digging for brickearth. In the face of earth seen in section at the time I refer to, the bones in the Saxon graves were exposed at a depth of about $1\frac{1}{2}$ to 2 feet, and some 4 feet lower the Roman skeletons were seen.

In ordinary dry states of the weather the earth above the skeletons showed no sign of having been moved, and there was nothing obvious in its condition to indicate in either the one case or the other that there had been any interment. The graves had been dug in homogeneous yellowish-brown brickearth, and there were no lines of stratification or stony beds cut across to betray the disturbance. But the loosening of the earth had permitted a more free percolation of surface-water in the graves, and had in this way produced a small change in the texture of the loam, which was indicated in damp weather by a slightly darker colour in the moved soil.

In view of these facts I attach no importance to the absence of any signs of disturbance in the soil above the skeleton at Barrington. I believe that the Ipswich skeleton occurred under exactly similar conditions. It showed, as I was informed, no signs of disturbance in the earth above the bones, which were in a small irregular depression in the underlying sand. This sand is that called by Searles Wood 'Middle Glacial'. The earth above the skeleton was simply 'soil', 'head', 'run of the hill', or 'trail', but there was, I feel sure from what I saw, no Boulder-clay overlying the skeleton.

T. McKenny Hughes.

February 28, 1912.

STRATIGRAPHICAL NAMES.

Sir,—I think Dr. Bather has done well to call attention to the growing necessity for some official control over geological nomenclature. The introduction of a new name for any stratigraphical unit ought to be regarded as a serious matter, which cannot receive too much

consideration, and it should certainly have the sanction of a responsible committee. This is desirable not only to prevent the duplication of names and the proposal of unnecessary names, but also on behalf of a good and necessary name, which would thus stand a better chance of being generally adopted.

Being myself responsible for the proposal of several stratigraphical names I can fully understand both the positive and negative advantages of submitting them to a committee, and one practice which such a committee could practically prevent, by refusing to sanction it, is that of giving formal geographical names to divisions which have no greater importance than zones.

Moreover, there are cases where the same stage is known by different names in different countries, and if such tribunals existed in two or more European countries they might combine to decide which of the two names should be adopted.

I think the committee might be appointed by the Council of the Geological Society and its members hold office for a term of years, and that it might consist of seven members, with the proviso that one was always chosen from the staff of the Geological Survey.

A. J. Jukes-Browne.

Torquay.
March 9.

OBITUARY.

R. B. BROCKBANK.

Born 1824. Died January 31, 1912.

The late Richard Bowman Brockbank, who died at The Nook, Crosby, near Maryport, Cumberland, on January 31, in his 88th year, was a much-esteemed member of the Society of Friends, and was well known in the district around Carlisle as an able farmer and breeder of excellent horses and cattle. To the geologist he is notable as the discoverer of the fact that the shales and limestone bands around Great Orton and Aikton, west of Carlisle, are of Liassic and not (as then supposed) of Carboniferous age. He called the attention of E. W. Binney to the subject, and Binney has described what he saw of the Lias of Cumberland in Quart. Journ. Geol. Soc., vol. xv, p. 549. More detailed observation, on the part of the present writer, has added but one section to those shown to Binney (see Geol. Survey Mem., *Geology around Carlisle*). For the ground is persistently drift-covered, and any sections in the underlying rocks are very few and small.

In addition to being shown the positions of sections in the Lias, I have to thank Mr. R. B. Brockbank for much information kindly obtained for me with regard to old borings and observations that would otherwise have remained unnoticed, and which have a special value in a district of this kind.

T. V. Holmes.

CHARLES ROEDER.

BORN JULY 22, 1848. DIED SEPTEMBER 9, 1911.

CHARLES ROEDER was a native of Gera, Thuringia, and came to this country when 21 years of age as a clerk in a Manchester shipping house. He later started in business for himself as an agent for several important Continental and English manufacturers.

He devoted a large measure of his spare time in research work of various kinds, geology, botany, philology, and history being his chief subjects. Prehistoric archæology, also, came in for a good share of his time in later life.

His geological investigations were by no means small, and one has only to peruse the Transactions of the Manchester Geological Society and various other local journals in order to gain some idea of his work in this science.

The sections of Upper Coal-measure and Permian strata exposed in cutting the railway from Fallowfield to Levenshulme, on the south side of Manchester, afforded him excellent opportunities to pursue one of his pet subjects. To him science is especially indebted for a knowledge of these beds. With unflagging energy he examined and measured this section inch by inch, collecting, often with considerable difficulty, the various fossils contained therein, afterwards forwarding the results of his labours to Messrs. Jones and Kirkby, Professor Geinitz, and others, for expert examination and identification. In his honour a new species of Ostracoda was named by Messrs. Jones and Kirkby, viz. *Carbonia roederiana*.

Mr. Roeder later presented a fine series of fossils from this and many other localities at home and abroad to the Manchester Museum.

J. W. J.

ROBERT CAIRNS.

BORN 1854. DIED DECEMBER 29, 1911.

BY the death of Mr. Robert Cairns, which took place from heart failure at his residence, Hurst, Ashton-under-Lyne, Lancashire loses a well-known local geologist. The deceased came to Ashton from Hawick, Roxburghshire, about 1875, and for many years acted as assistant to Mr. Abraham Park, J.P., at the Albion Schools. This position he relinquished later in order to take over the headmastership of the Hurst Undenominational (Old British) School, which he held for the past thirty-five years.

He was a man of wide culture and endowed with a strong personality that brought him numerous friends. As an enthusiastic geologist and conchologist he made a name for himself among a wide circle of local naturalists.

For many years he assiduously collected fossils from the numerous coal-pits lying between Ashton and Oldham, and formed an extensive and valuable collection of fish and other remains. During the sinking operations of the Ashton Moss pit, at Audenshaw, he took advantage of the excellent opportunity afforded of collecting and studying the various fossils met with, and by his unwearied labour got together a fine series of interesting specimens. He also collected extensively

from the well-known 'marine band' in the Middle Coal-measures exposed on the banks of the River Tame at Dukinfield, *Aviculopecten cairnsii*, Bolton, from this horizon being named in his honour.

Further afield the Mountain Limestone areas around Castleton, Derbyshire, and Clitheroe, Lancashire, came in for a large share of his spare time, and by his keen perseverance he amassed a considerable collection of interesting forms from both these places.

When he began to seriously take up conchology as his hobby the exigencies of space led him to hand over *en bloc* his entire collection of geological specimens to the Manchester Museum, an acquisition which was gratefully accepted by the Museum authorities as a very welcome addition.

Though he could never be persuaded to write anything about his varied experiences, he was ever ready to place his wide and practical knowledge at the disposal of his friends.

J. W. J.

GEORGE ATTWOOD,

F.C.S., M. Inst.C.E., F.G.S., etc.

Born 1845. Died February 9, 1912.

Mr. George Attwood, J.P., who died on February 9 last at his residence, Steyning Manor, Stogursey, Somerset, was the son of the late Mr. Melville Attwood, F.G.S., etc., mining and civil engineer, and nephew of the late Professor Edward Forbes, F.R.S., Edinburgh, and David Forbes, F.R.S. Mr. Attwood was born at Carlisle in 1845, and educated at Edward VI's Grammar School, Lichfield. He was a member of the Institute of Civil Engineers, the Institute of Mining and Metallurgy, and the American Institute of Mining Engineers; Fellow of the Geological, Chemical Faraday, and Zoological Societies, and of the Society of Arts; a member of the London Chamber of Commerce; and Justice of the Peace for the Province of British Columbia. He commenced his professional career at the age of 16, under his father and Mr. W. W. Palmer, C.E., in California and Nevada, and two years later was appointed assayer, metallurgist, and chemist to the Ophir Company, Great Comstock Lode, Nevada, U.S.A. He constructed and designed large metallurgical, electrical, and water works, aerial tramways and railways in Nevada, California, Mexico, South America, Canada, South and North Africa, and practised as a consulting civil and mining engineer at 56 Moorgate Street, E.C., under the name of Messrs. Attwood & Hopper. Mr. Attwood also found time for considerable literary work, being author of numerous scientific publications and papers on geology, mining, mining plant, metallurgy, assaying, meteorology, microscopic research, etc. He was one of three or four surviving male descendants of an ancient Worcestershire family which came originally from Brittany, whose name 'De Bois' was anglicized into 'Attwood'. Members of the family were knights of the shire as early as 1327. He married first Maria Louise (who died in 1892), daughter of James Tansley, F.S.A., of London, and secondly Charlotte Caroline, daughter of William Burchell, late Under-Sheriff of London.

The late Mr. Attwood was frequently called upon to advise British

mining companies when in some difficulty. This was notably the case in the early seventies with the Emma Silver Mining Company, Ltd., of Utah, U.S.A., floated by Baron Grant, and sold by him for £1,000,000 sterling. Mr. Attwood was asked to visit the Emma Mine and report upon it. He did so, and what he had to say was distinctly unfavourable. On many subsequent occasions the services of this distinguished engineer were in request, and his reputation was always of the very highest. The mining profession is greatly benefited by the association of such reliable and honourable men as the late Mr. George Attwood.—From the *Mining World*, February 24, 1912.

MISCELLANEOUS.

A Deep Boring in Gotland.—A boring recently completed in the grounds of the cement factory at Kopparsvik just south of Visby is of interest, first as the deepest boring yet effected in Sweden, exceeding that at Kiruna by 29 metres; secondly, as passing from the Silurian (Lower Wenlockian) through the Ordovician and possibly Cambrian to the gneiss floor. Started last year by the factory to discover the depth of its clay, the work was ultimately finished by the Geological Survey of Sweden, which will study and publish a report on the cores. The total depth of the borehole is 390 metres (*circa* 1,275 feet) below sea-level. Clay persisted to a depth of 140 metres, and was followed by 100 metres of pure limestone; then came 40 metres of shales, and, at a depth of 280 metres, sandstone mixed with shales. The gneiss was touched at 386 metres. At intervals below the depth of 200 metres a strong smell of petroleum was noticed. The boring was carried out by the Swedish Diamond Rock-boring Co., Stockholm. We may expect that, in the competent hands of our Swedish colleagues, the cores will give much-needed information as to the passage beds between Silurian and Ordovician in this part of the Baltic.

Croydon Bourne.—It is not surprising after the heavy rains of the past three months that the Croydon Bourne reappeared on February 7. The outbreak was predicted by Mr. Baldwin Latham, M.Inst.C.E., who has on fourteen previous occasions, 1877–1910, successfully foretold the time when this 'Woe Water' would break out.

Royal Society.—As announced by the President, Sir Archibald Geikie, in his Anniversary Address delivered on November 30, the Royal Society will celebrate its 250th birthday on July 15 of this year. Although the Society originated from meetings held by certain Natural Philosophers about the year 1645, it was not until July 15, 1662, that the Charter of Incorporation passed the Great Seal and the Society was fully established. Among the original Fellows whose labours and writings dealt to some extent with matters geological, were John Aubrey, Robert Hooke, Sir William Petty, and Sir Christopher Wren. The Society has invited the chief universities, academies, scientific societies, and other institutions in this country, in our Colonial Dominions and elsewhere abroad, to send delegates to the meeting. It has also been arranged to issue a new edition of *The Record of the Royal Society*.